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Navigational Radar in Merchant Ships
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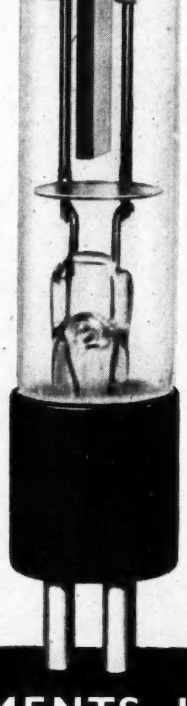

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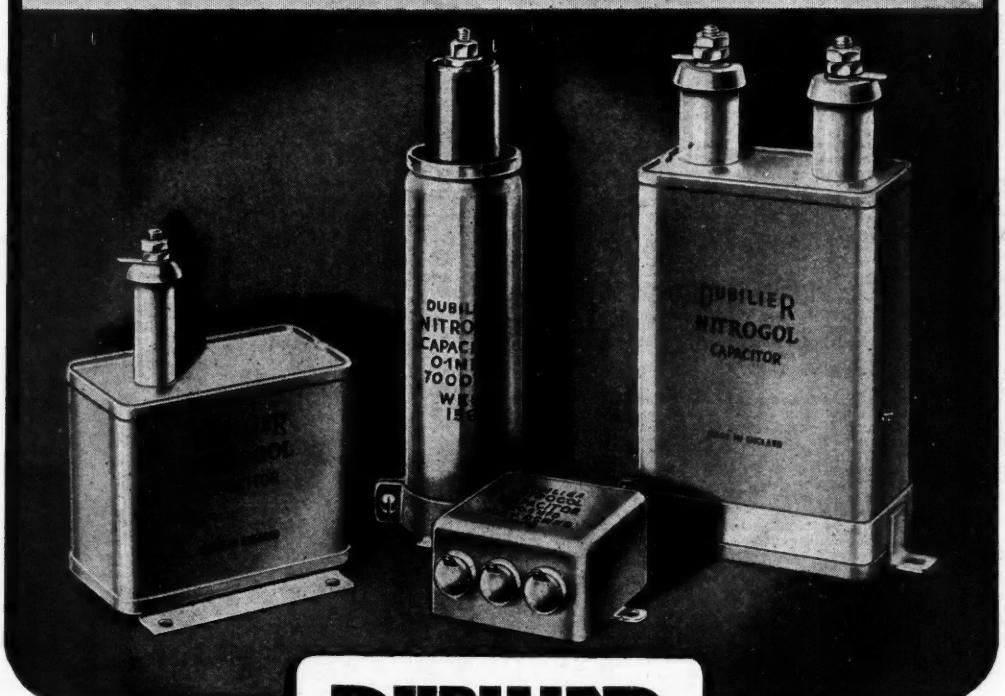

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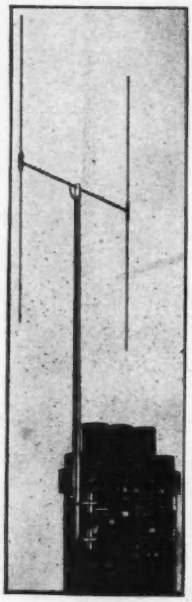

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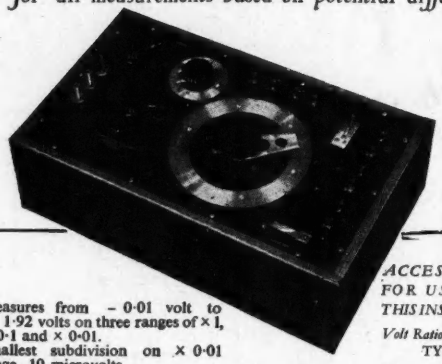

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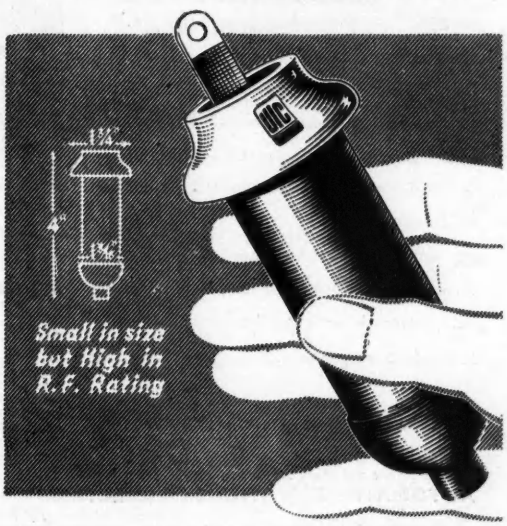

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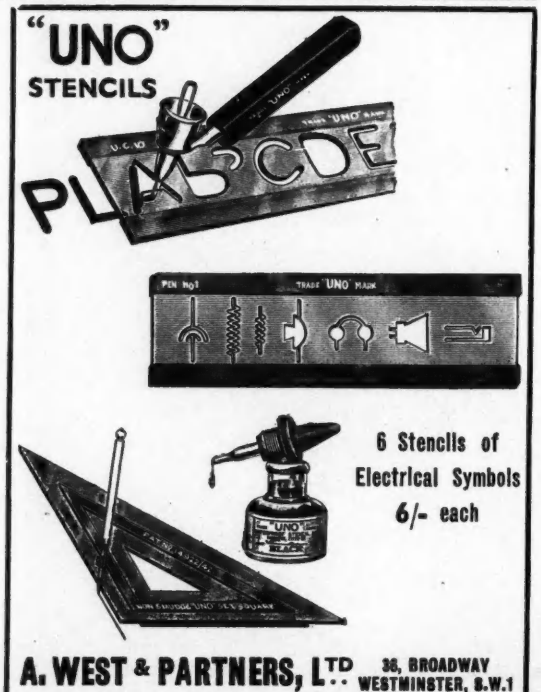

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Electronic Engineering

SEPTEMBER, 1946

Volume XVIII. **No. 223.**

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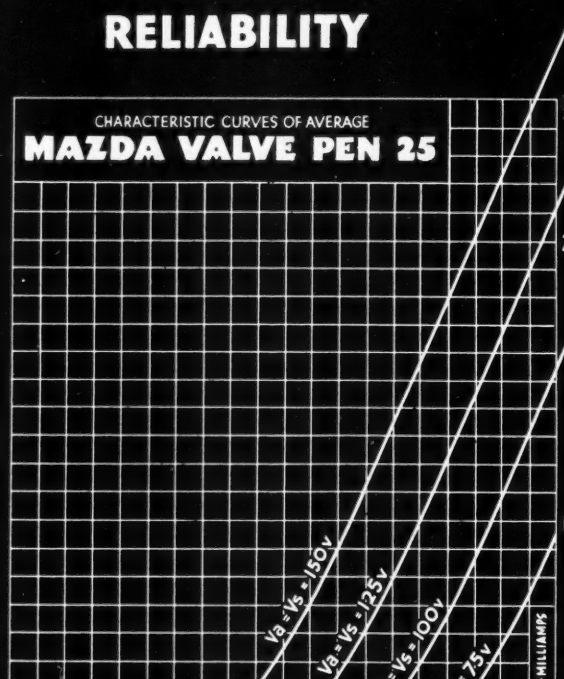

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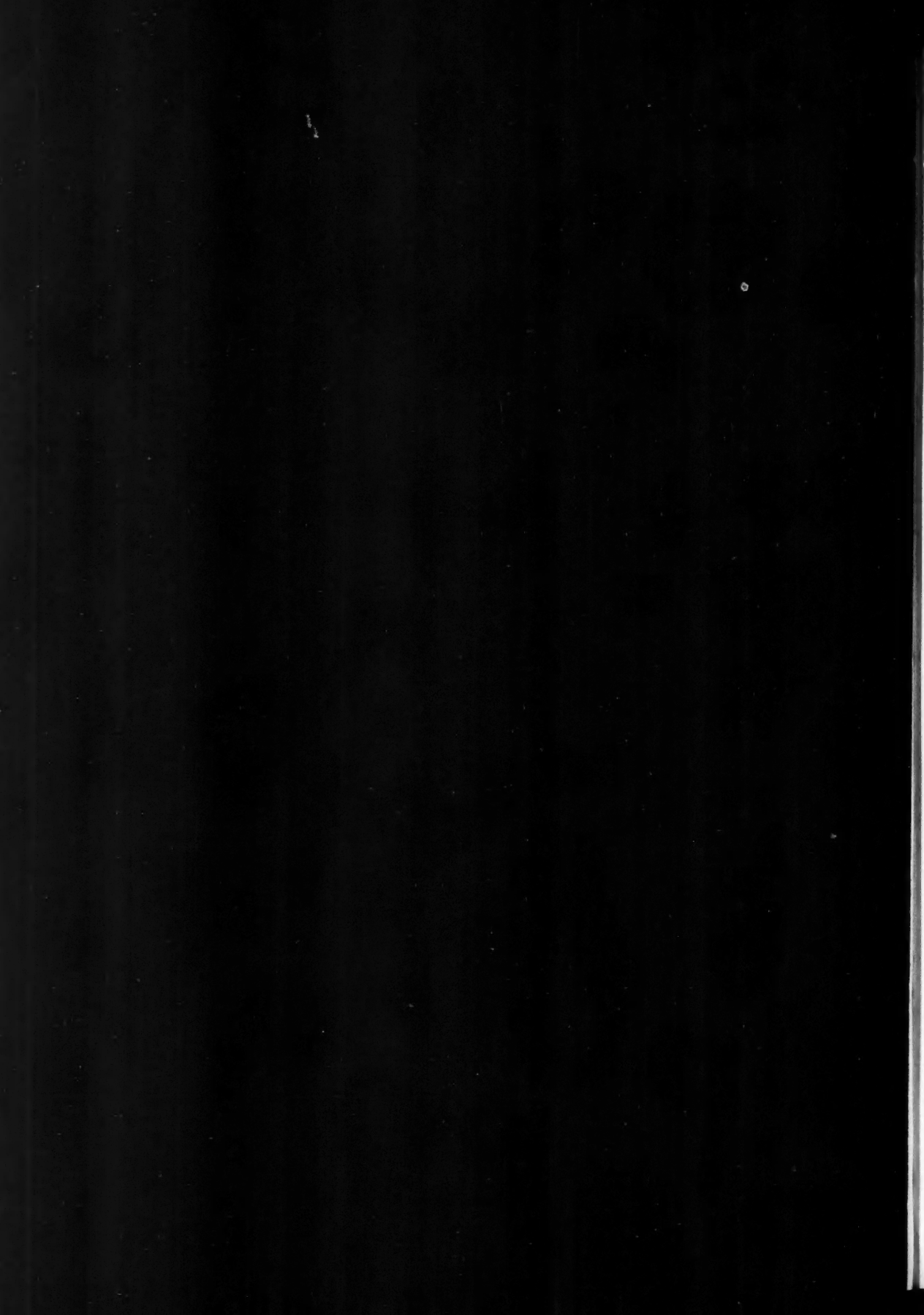

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Echo

A reader has written that while he supports in principle the criticism of the recent House of Commons attacks on manufacturers*, he thinks that in the case of the Hearing Aid manufacturers the writer chose to champion an unfortunate cause.

He claims that the average deaf-aid " containing, perhaps, a couple of valves and small transformers, a few odd condensers and resistances, together with a microphone and earpiece of no special merit " could have been bought for a few pounds before the war, and that the retail price compares unfavourably with that of a super-het.

The smaller demand for the hearing-aid is, in his opinion, apparent rather than real and is due to the excessive price charged.

He concludes " After all, the admission that a Utility Model can be produced for £10 now is also an admission that it could have been produced for £7 or less before the war, when the manufacturers could hardly blame Government control for preventing them."

This letter has been referred to a Director of one of the leading hearing - aid manufacturers. Unfortunately his reply cannot be quoted in full, but after stating that 95 per cent. of the present-day reputable hearing aids contain piezo microphones and miniature valve with best quality components, he goes on :

" In criticising the price of £10 proposed for the Utility hearing aid, your reader is at a disadvantage in not knowing that in 1939, valve hearing aids were sold for as little as £10 10s. retail, and through hospitals for £6 only. In that year, I presented to the National Institute for the Deaf a draft of a scheme for taking care of poor deaf persons throughout the country but the scheme was turned down. The scheme could have provided all and more than the Ministry of Health's scheme plans to provide in 1948 if the Act becomes Law. In mentioning prices, he is obviously referring to those dishonest companies who have obtained their business by extensive advertising. It is natural that he should know the methods of the advertisers rather than that of the companies who have worked almost entirely by recommendation."

It is also pointed out that the present obstacle is not the price or the performance of the instrument but the instrument itself. " The deaf have been more easily persuaded that they could hear with a worthless but small device than they were persuaded with a larger but helpful device." The process of educating the deaf is a slow and expensive process, and the deaf public has had to be sold on the idea of a good reliable hearing aid.

Finally he adds : " The Ministry of Health agree that the propaganda was unfair and ill-timed and tell me that they were not responsible for the statements made." Which brings us back to the theme of the original article : Responsible people should not make irresponsible statements.

*See " Fair Play "—July issue.

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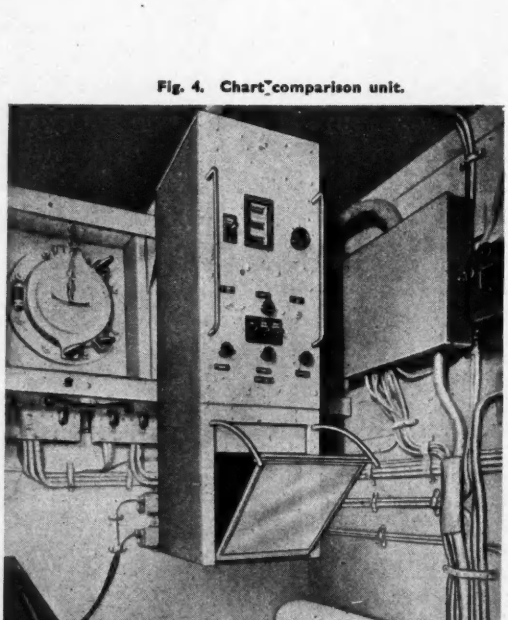
Fig. 3. Main P.P.I. unit.

Navigational Radar Equipment

(For details refer to article on opposite page)

Fig. 2. Main console of radar set.

Fig. 4. Chart comparison unit.



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Navigational Radar in Merchant Ships

By E. D. HART, M.A., M.I.R.E.*

1. An Early Equipment

DURING the past year the experience of the three Services has been turned to account in designing and fitting radar sets as navigational aids to merchant ships. One of the first to be so fitted was the whaling factory *Southern Venturer* which is now in the Antarctic. The set fitted was originally designed for naval use, but was found very suitable for ordinary navigational use. Although it has already been described,[1] a brief account of its working may be useful as it is the basis of the other sets now in use and the block circuit shown in Fig. 1 may be taken as representative in broad details of all present navigational radar sets.

A pulse generator locked from the 500 c/s. supply feeds the transmitter modulator and the time base for the viewing tubes. The modulator operates on the magnetron transmitter which radiates via a rotating cheese aerial whose revolutions are synchronised with those of the radial time base. The same aerial receives the returning signal which is diverted by a transmit/receive switch in the waveguide to a crystal detector also supplied from a reflector klystron local oscillator. An I.F. amplifier diode second detector and video amplifier feed the signal to the display tube which is also controlled in the north-south sense from the ship's compass, either gyro or automatic transmitting magnetic. A.F.C. applied to the local oscillator maintains the correct intermediate frequency. Many circuit refinements, such as A.G.C., special gain controls, monitor circuits, etc., are also fitted, and as may be expected, the detailed arrangements vary in the different types of equipment.

2. Recent Tests and Demonstrations

While this naval radar set is satisfactory for merchant ship use, it is capable of improvement, and as a consequence the Ministry of War Transport has drawn up the U.K.R.M.T. Performance Specification for a desirable mercantile marine navigational radar equipment and the Admiralty Signal Establishment have made experimental sets to this specification. In addition to making the equipment more suitable for operation by relatively unskilled personnel, the specification reduces the minimum useful range so that navigation in crowded waters is possible. Demonstrations of these experimental sets have been given to shipowners and radio manufacturers in January and May of this year, the first being on H.M.S. *Pollux* from Sheerness, and the second on H.M.S. *Fleetwood* from Portsmouth. These demonstrations showed to shipping interests the use of radar for navigation in narrow waters, for general reconnaissance in open water, and its great use in foggy or other conditions of restricted visibility. The radio industry was invited to examine the apparatus and see the form in which commercial packaged units might ultimately be manufactured.

The *Pollux* tests were done with a purely experimental equipment which was not intended to be, in any way, a model for manufacture, emphasis being on the navigational possibilities, but the demonstrations were most successful and aroused great interest. Comprehensive operational tests and a series of blind runs showed that crowded channels could be navigated using only radar information. Brief descriptions have now been published in the technical Press.[2] On H.M.S. *Fleetwood* a more fully engineered version was installed,[3] and incorporated several modifications and improvements; in addition to having a more convenient disposition of units and a more compact layout. An automatic performance monitor was also included. In these last trials emphasis was on the equipment and its comparison with the original naval set, not on the navigation, and it is proposed to describe briefly its salient points.

3. The Latest Equipment

3.1 General

As with the first experimental model and the earlier naval set a wavelength of 3 cm. is used, with a peak R.F. power of 30 kW. The pulse length is 0.2 μsec. at a recurrence of 1,000 c/s.—obtained by doubling the frequency of the 500 c/s. generator supply. A motor generator has to be used as the ordinary shipboard supply is low-voltage D.C. and the use of 500 c/s. allows the power supply components to be smaller than usual and, incidentally, the easy use of 1,000 c/s. recurrence. The power consumption of the complete set is 3½ kW, well below the maximum specified of 5 kW. The equipment is arranged in four sections, masthead aerial, main console, main display P.P.I. unit and chart comparison P.P.I. unit. The main console is intended to be mounted in any convenient part of the ship, the main display near the navigating position and the comparison unit in the chartroom.

3.2. Mechanical Arrangements

The masthead unit consists of the aerial itself, the reflector being 5 ft. long and 3 in. high, the ½-h.p. motor driving at between 20-70 r.p.m. with a large reserve of power in all conditions of windage, and the magslip for synchronising the rotating time base coils in the display units. Rotating contacts provide the controlling signals for the ship's heading marker and the performance monitor. The aerial is fed by a waveguide via a rotating joint in the pedestal and because of the long run of guide to the main console, special arrangements are taken to prevent moisture deposition. A heating wire, about 6 W/ft. length, of the type used for soil heating, runs in the lagged guide and air is blown continuously through its 68 ft. length. The heating obviates the necessity for drying the air, which has hitherto had to be done with blown waveguides.

The main console (Fig. 2) is intended to be run unattended, controlled from a remote position. It contains the monitor unit, control gear, starters, voltage regulators, etc. (top drawer); the power pack operated from 180 V, 500 c/s. and the main 45 Mc/s. I.F. amplifier (second drawer down); the R.F. chassis including the magnetron transmitter and klystron receiver (third drawer down); and the motor generator and hydrogen thyratron modulator (bottom drawer). It is constructed on the lines of the standard steel filing cabinet with the units sliding as drawers and a roll-front can cover all the panels preventing unauthorised access. In the illustration the power unit and I.F. drawer and the motor generator drawer are both withdrawn, while the waveguide may be seen on the right of a panel and emerging at the top. The I.F. rather than the video is fed from the main console to the display units which each has its own final I.F. stages and second detectors, to avoid

* Marconi Instruments, Ltd.

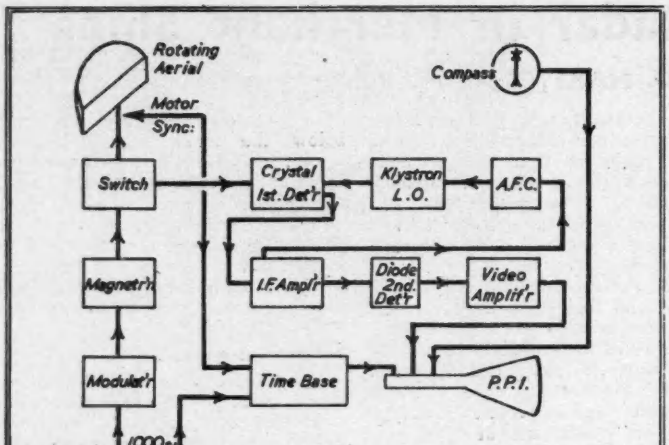


Fig. 1. Block circuit diagram of typical radar set for navigational purposes.

the use of high gain video amplifiers which would be difficult to make with the required bandwidth.

The main display unit (Fig. 3) contains three panels in addition to the main one holding the C.R. tube and its immediately associated components. They comprise a time base and strobe unit; a mixer unit which is fed by I.F. from the main I.F. amplifier in the console and provides video output; and a sync. control unit which performs multifarious duties concerned with holding the sync. to the displays through the automatic performance monitor (*see* Section 4.1). In the final version of this display unit it is suggested that the majority of the controls can be preset and concealed, leaving only the essential ones accessible, so as not to confuse the operator.

The last of the four main units is the chart comparison unit (Fig. 4) which includes the actual 9-in. diameter C.R. tube, power units, 45 Mc/s. I.F. amplifier and second detector, time base and strobe circuits. The one now in use differs slightly from that shown in the figure, but performs exactly the same functions.

4. Some Special Features and Details

4.1. Automatic Performance Monitor

The U.K.R.M.T. specification states that the overall performance of the radar should be monitored in such a way that if the performance drops, a warning signal is given or the display is unmistakably affected. In the *Fleetwood* model, the sync. to the displays is cut off if the performance falls below a minimum level, the system being as follows: Astern of the aerial and about 10 ft. away is mounted a horn aerial and resonant cavity (Fig. 5). The horn receives from the radar aerial a pulse which is rectified by the crystal in the vertical stub and passed on to the first amplifier which gives as output a D.C. signal of level proportional to the received (*i.e.*, the transmitted) power. Following this, the spark gap in the horizontal stub is excited, generating a standard R.F. signal in the cavity which is radiated by the horn and picked up by the radar aerial. From a second detector of the radar receiver a pulse is taken to the second amplifier which also gives a D.C. output, but proportional to the sensitivity of the radar receiver. Both the D.C. signals are then fed to an electronic multiplier to produce an overall performance level which is used to hold on the relay feeding the sync. It is clear that should either the transmitter power or the receiver sensitivity fall, the sync. relay opens and the displays disappear. This sequence of operations takes place while the aerial swings through the 15° of arc directly astern, during which period the receiver gain is turned fully up and no observation can be taken on the P.P.I. It is felt that the loss of this 15° astern is of little consequence, especially as, in the usual aerial mounting position, there tends to be a dead space in this region, due to the ship's funnel. This system of monitoring is rather complex and in all employs about 20 valves, but has the merit of checking the whole of the R.F. and I.F. circuits of the equipment.

Another checking circuit is arranged to display on one of the C.R. tubes a series of vertical lines of the same height. These represent voltages at various important points in the equipment, scaled down to a common level, and should faults occur their height varies and draws the attention of the operator.

4.2. Chart Comparison Unit

On this unit an arrangement of mirrors, one half-silvered, allows the P.P.I. display to be viewed superimposed on the navigational chart below, so that the "pips" on the display can be compared with the fixed points marked on the chart (Figs. 4 and 6). Modified Admiralty charts are employed, special colourings and markings being introduced to render them easily readable in the subdued light necessary for the P.P.I. Additional information has been added to the charts, such as land contours near the coast—these tend to appear very well on the display, and it is hoped, in order to avoid duplication, that these special charts will also be acceptable for all ordinary navigational purposes.

The chart comparison unit includes a control which can continuously alter the scale of the display from 1/18,000 to 1/630,000 (ranges 2,000-70,000 yards), a motor-operated strobing ring which can be expanded to meet any point on the display so that its range can be read off from a counter, fixed ranging rings which can be switched in and out at will, and provision for superimposing compass bearings on the display. Should it be needed to observe the tube display by itself, without superposition on the chart, the screen may be viewed horizontally (Fig. 6) when the half-silvered mirror is laid flat. As this would mean the image is only reflected once, it would be laterally inverted, but the operation of pulling down the front mirror to the horizontal position reverses the direction of rotation of the scanning coils on the C.R. tube, which corrects matters.

Means are provided for causing the centre spot of the display to be expanded to a 1-in. circle. Although this distorts the picture and renders the chart comparison feature inoperative, the angular separation of objects

close to the ship is greatly increased and their observation facilitated. The top of the display is always true north as a controlling signal is obtained from a transmitting compass (normally part of the ship's usual navigation apparatus), while the brightening of a radial line at each revolution of the time base shows the ship's heading. Lights fitted in the bottom of the unit illuminate the chart below, their brightness being adjustable to suit the P.P.I. display. Most of the details above, with the exception of those applying specifically to the chart comparison feature, are repeated on the main display unit, but whereas the chart comparison unit has a standard C.R. tube, the main unit has an experimental orange fluoride screen which gives an exceptionally fine picture.

4.3. Swept Gain

In order to prevent paralysis of the receiver by powerful echoes from nearby objects, a swept gain circuit is provided. This reduces the receiver gain by applying a long triangular pulse to some I.F. stages, so that the gain is reduced to a low level immediately after the transmitter is pulsed and then slowly rises to normal at a predetermined rate—usually about 10 db. per 1,000 yards with the aerial at a height of 50 ft. By this means, the sensitivity of the set for near objects is lowered and the maximum sensitivity only applied to distant objects. Both this swept gain circuit and an auxiliary instantaneous A.G.C. circuit help to remove sea clutter, caused by echoes from the tips of waves and broken water.

5. The Future of Navigational Radar

It is hoped that radio manufacturers who have attended these trials will produce their own versions of sets meeting the U.K.R.M.T. specification and which will be suitable for selling as packaged units to shipowners for installation in ordinary small and medium sized cargo ships. Although the Admiralty Signal Establishment experimental model meets the Performance Specification in most respects (*see* Appendix), it is intended only as a guide to manufacturers and is not a rigorous production prototype. Some additional features which are mentioned in the specification might well be included in future commercial sets. An audible warning device which sounds should echoes appear between, say, the ranges of 2,000 and 5,000 yards would obviate the continual watching of the P.P.I. in open waters. An hour-meter on the equipment would time the length of operation and allow valves, the magnetron and the modulating thyratron in particular, to be changed before they failed in service. Heaters in all the units could be switched on when the equipment is not in use and the condensations of moisture thus prevented. Many minor circuit improvements are doubtless possible and a great amount of work is necessary to provide simple and reliable performance checking.

By the co-operation of shipowners, ships' personnel and radio manufacturers, it is certain that navigational radar can be an invaluable tool to the mercantile marine. Trinity House has already helped by fitting corner reflectors to many buoys in the Thames Estuary and laying them in patterns so that they show up clearly on the P.P.I.—a recent international conference has decided that corner reflector buoys should be arranged 1,000 ft. apart in such patterns—and the extensions of such facilities will encourage the use of radar. All interested will look forward to the future with the assurance that the work done by the Ministry of War Transport and the Admiralty Signal Establishment has laid a firm foundation for continued development.

The author's thanks are due to the Captain Superintendent, Admiralty Signal Establishment, Haslemere, for permission to use photographs and information.

Appendix

A tentative specification of the equipment described above is as follows:

1. Wavelength, 3 cm.
2. Peak power, 30 kW.
3. Pulse length, 0.2 μsec.
4. Recurrence rate, 1,000 c/s.
5. Azimuth beamwidth, 2°.
6. Elevation beamwidth, 35°.
7. Aerial rotation speed variable between 20 and 70 r.p.m.
8. Range accuracy, 50 yards.
   Range discrimination, 50 yards, minimum, 50 yards.
9. Bearing accuracy, 1°.
   Bearing discrimination, 2°.
10. P.P.I. size: 9 in. diameter.
    Scales: *Main P.P.I.* 2,000 yards; 15,000 yards; 45,000 yards.
    Chart Comparison Indicator: 2,000-70,000 yards, continuously variable.
    Linearity: 1 per cent.
11. Power consumption, 3½ kW.

References

[1] *Wireless World*, 52, 66-7, February, 1946.
[2] *Wireless World*, 52, 89, March, 1946.
[3] *Wireless World*, 52, 201, June, 1946.

Fig. 5. Block circuit diagram of automatic performance monitor.

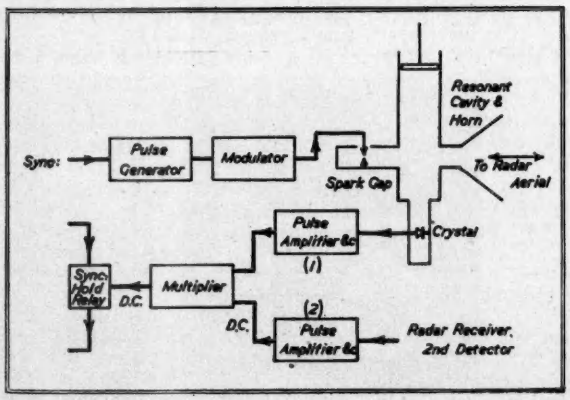
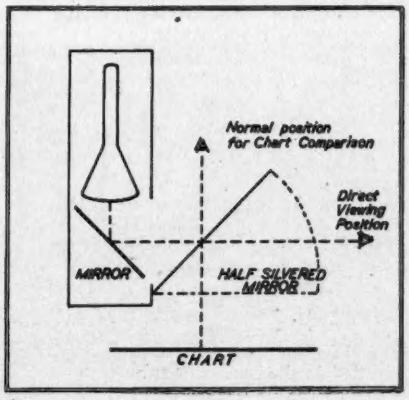


Fig. 6. Optical system of chart comparison unit.



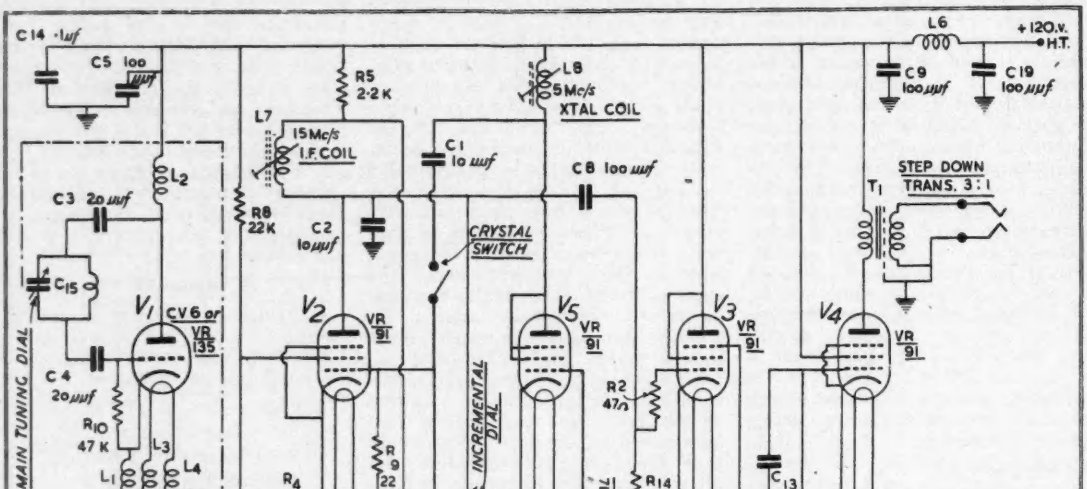


Fig. 1.

A Wavemeter for the Ultra-Short Band

By J. BANNER, M.B.E.*

DURING 1941 operational requirements made necessary the design of a wavemeter covering the following requirements :—

1. The frequency measurement of a pulse modulated transmission over the band 155 to 255 Mc/s. to an accuracy better than 0.25 Mc/s.

2. The radiation of a transmission to the same accuracy as above for the purpose of testing super-heterodyne receivers with the requirement that under operational conditions the radiation should not be detectable by the enemy.

3. The short term stability of the instrument to be better than 0.1 Mc/s.

4. The instrument should be capable of being operated and handled in the normal service manner by maintenance personnel both on shore and on sea.

A brief survey of existing wavemeters showed that instruments in production at that time were incapable of adaptation to fulfil the stated requirements. Work was, therefore, commenced on a prototype instrument which has certain novel features. Before describing the instrument itself it might be of interest to describe the radar equipment which this wavemeter was designed to serve.

This consists of :—

(a) A common transmitter-receiver aerial.

(b) A multi-stage super-heterodyne receiver using two R.F. stages.

(c) A squegging-oscillating type transmitter developing some 8 kW peak power with a pulse of approximately 1.8 micro-seconds duration, the transmitter firing at a repetition rate of roughly 500 c/s.

(d) A 6-in. cathode-ray tube indicator with the necessary time-base generator.

(e) Power supplies, voltage regulators and ancillary equipment.

To obviate the transmitter power entering and thereby damaging the receiver and conversely the received signal entering the transmitter, a device using quarter- and half-wave length transmission lines in conjunction with spark gaps, and known as "the common T and R box," had to be embodied in the equipment. In view of the design of this box, *i.e.*, critical length transmission lines with their attendant frequency selec-

* R.F. Equipment, Ltd., Hirwaun, Glam.

tive properties, it was important that the transmitter and receiver tuning should be held to the optimum frequency to which the box had been designed. It was therefore desirable for the wavemeter also to supply a signal of the desired accuracy to check receiver functioning. Consequently the wavemeter design followed the lines of a conventional super-heterodyne receiver and also incorporated a crystal monitor.

The valve arrangement was as follows (Fig. 1):—

Triode oscillator V_1 using a VR135, the frequency being variable over the band 140 to 240 Mc/s. by the main tuning dial, the output of this oscillator being fed by cathode coupling to a VR91 mixer valve (V_2). Next, a tuned circuit connected to the anode of the mixer with its mid-point of resonance set at 15 Mc/s. and being capable of variation plus or minus some 3 Mc/s. and controlled by means of an incremental dial. This tuned circuit is coupled in a conventional manner to a VR91 (V_3) infinite impedance detector, the output of which is taken to a VR91 amplifier output valve (V_4) and thus via an output transformer to a service type head set.

The remaining VR91 valve (V_5) is used as a conventional 5 Mc/s. crystal oscillator generating harmonics over the band 155 to 255 Mc/s., the output being coupled for calibration purposes into the mixer valve and, by means of a switch, the crystal may be switched on or off at will. The power supply is normally obtained from self-contained batteries, but by means of an adaptor unit the instrument can be operated on various voltages between 80 and 230 V. External transmissions can be picked up by means of a short length aerial fed direct into the grid of the mixer valve. The signal generated by the oscillator valve VR135 (V_1) is radiated in a like manner via a 1 μF condenser again coupled to a short aerial; the aerial, loaded by this method, shows no appreciable effect on the oscillator tuned circuit. To achieve the stability required it is necessary to construct the oscillator tuned circuit in an extremely mechanical robust manner, also to provide an instrument-engraved dial of the Vernier type. Tuning of the 15 Mc/s. I.F. coil (L_7) is by means of a 4 to 50 μF condenser (C_{18}) connected between anode and earth. A very pleasing feature of the design is that the zero setting and zero tuning point of this dial, *i.e.*, the one corresponding precisely to the I.F. of 15 Mc/s., can be accurately checked by tuning to the loudest signal generated by the 5 Mc/s. crystal oscillator and, in the event of the dial calibration being in error, the iron dust core of the I.F. coil can be adjusted to reset the dial. The layout of the front panel can be seen from the photograph of Fig. 2, and Fig. 3 shows the interior.

The operation is as follows:—

(1) *As a Wavemeter.* The small incremental I.F. tuning dial is set at 0, the main dial is rotated and the point noted at which the signal is received. The control switch is then turned to the position marked CRYSTAL, the main dial being again rotated until a crystal beat nearest to the position of the desired signal on this dial is tuned in; the crystal is then switched off and the wanted signal tuned in by rotating the incremental dial which, as stated before, tunes the I.F. circuit. The frequency of the signal is then given by the main dial calibration reading plus or minus the reading on the small incremental dial. We have thus achieved a coverage of 6 Mc/s. spread over 180° of incremental dial reading.

To take an example, suppose the desired signal comes in at a position near the 165 Mc/s. point on the main dial with the incremental dial set at 0. The switch is now turned to CRYSTAL and the main dial rotated until a crystal note is heard at the 165 Mc/s. marking. The crystal is now switched off and the small dial rotated until the signal is heard at its loudest. If the incremental dial now shows plus 1.5 Mc/s. the frequency of the desired signal is 165 plus 1.5, *i.e.*, 166.5 Mc/s. It should be noted that during operation as a wavemeter the VR135 oscillator is working at 15 Mc/s. below the frequency of the incoming signal, the main tuning dial carrying the appropriate markings. Full accuracy of the wavemeter is maintained with falling battery voltages since reference is made in each case to the crystal oscillator.

(2) *Operation as a Signal Generator.* A further set of markings on the main tuning dial refer to the actual frequency at which the oscillator is working and it is merely necessary to turn the main dial to the appropriate marking when the oscillator will radiate on its fundamental frequency (the crystal oscillator being switched off). The dial calibration can, of course, be checked at 5 Mc/s. intervals throughout the tuning range by means of switching on the crystal oscillator and, with the incremental dial set at zero, crystal beats are heard and used to check calibration.

When used as a signal generator the maximum output is of the order of 10 db. down on 0.1 V feeding into a 47-ohm termination.

On test, a production instrument being used in the field showed a stability of better than plus 1,000 cycles over a continuous running period of four hours. In service the instrument proved to be reliable, robust, and simple to use.

Fig. 2. Front panel of wavemeter.

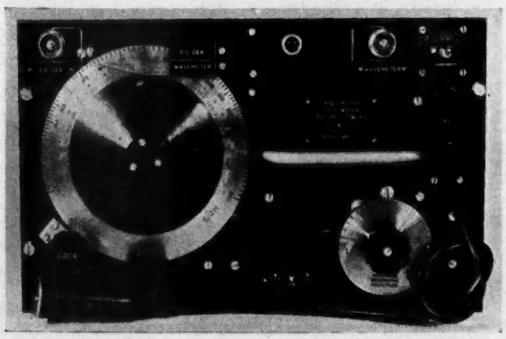
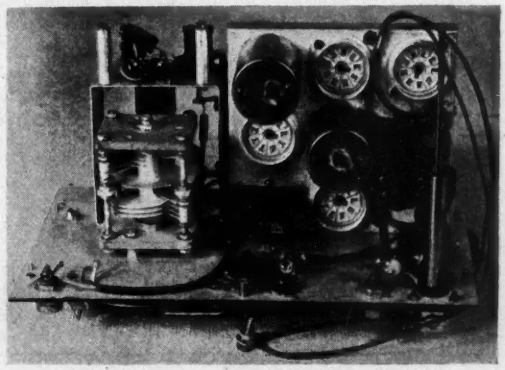


Fig. 3. Internal view looking down.



Capacity-Current Heating in the Rubber Industry

By T. H. Messenger, M.Sc., A.R.C.S.*

THE vulcanisation of rubber is a process usually involving exposing it to a heat treatment more or less prolonged, and as rubber compositions are normally electrical non-conductors, rubber vulcanisation would seem to be a logical field for the extension of high-frequency heating methods.

The pioneer worker in this direction was H. A. Leduc, who was endeavouring to shorten the very long vulcanisation periods, up to 16 hours, needed by massive rubber-covered rollers. Adapting the high-frequency oven of R. A. Dufour[20], he was soon obtaining encouraging results, and was able to stage an exhibition of his process in December, 1935[21]. Others followed the lead and there is now a voluminous literature on the subject.

In general the frequency of the alternating field applied in rubber technology is not a critical factor, frequencies ranging from 1 Mc/s.[22] to 200 Mc/s.[17] being reported. An unusual adjunct to high-frequency vulcanisation has been suggested by the Patentverwertungs - G.m.b.H. "Hermes"[20] according to which the rubber is subjected not only to a high-frequency electric field, but to the action of mechanical vibrations also, of a frequency of the order of that of ultra-sound, *i.e.*, about 20,000 per sec.

Although the main use of capacity-current heating in rubber technology relates to hot-vulcanisation, it is not confined to this particular application, as will appear from the following broad survey of recorded instances of its proposal for use in rubber.

1. Latex Processes

When latex is exposed to the action of a high-frequency electric field the entire body of the liquid is heated, and if the electric field is uniform, the degree of heating also will be uniform. The heating action arises from two sources, namely a Joule effect in the serum and a dielectric loss in the rubber. Since the rubber particles are not electrically neutral they are constrained to undergo rapid movement as well as experiencing a rise in temperature. These effects can be utilised to coagulate the latex.[26, 27]

By the addition of certain agents latex can be rendered heat-sensitive, *i.e.*, subject to coagulation under the influence of a rise in temperature, but at present industrial applications of this are limited to relatively thin goods, since a long time is needed for heat to penetrate into a thick mass of latex. Moreover, if a mass of heat-sensitised latex be heated from the outside, or by immersion in hot water, the coagulum tends to be hollow and to be more compact at the outside, because of the greater tendency to coagulate in these latter regions. Coagulation in a uniform high-frequency field, however, is not only rapid, but is also uniform throughout the mass[26, 31]. In apparatus for conducting the operation at least one of the electrodes is formed by a bounding wall of the vessel, or by an inlet pipe extending into the vessel[4, 7, 8, 9].

The concentration of latex by evaporation also lends itself readily to the application of high-frequency technique. The method proposed is to expose the latex in a film on the inner wall of a tube or drum of metal, the metal container being suitably insulated, and the whole apparatus set in an electric field of high frequency. Very rapid and uniform heating is claimed[28]. Concentration can also be effected by bubbling air through the hot latex[26].

The high-frequency heating of latex, whether for coagulation, concentration, or for the formation of particular goods, has been made the subject of several patent claims[5, 6, 10, 12].

Latex-dipped goods can be coagulated, dried, and vulcanised in one operation[31].

By forcing the heat-sensitised latex through nozzles, high-frequency heat coagulation can be utilised to form rubber thread. It is stated that with a head of 2½ kg. a speed of extrusion of 3-5 metres per min. is obtainable and the electric energy consumed is so small as not to affect the price of the thread[5, 29, 37]. Using a battery of 15-20 nozzles and a 100-watt oscillator Leduc produces thread 1 mm. in diameter at a rate of several metres per second[34]. By altering the shape of the nozzles other effects, *e.g.*, tape and sheet, can be produced[5, 31].

Sponge rubber made by latex processes assumed considerable importance in pre-war years, and forms a profitable field for capacity-current heating[20, 27]. For example, in the production of sponge rubber sheeting an electric field is produced by an oscillator operating on a wave-length of about 27 metres (corresponding to about 11 Mc/s.) with an input of 6 kW and is connected to two horizontal plate electrodes, each about 4 in. by 2 ft. 6 in. and separated from each other by a vertical distance of 3 in. A frothed, heat-sensitised latex mixing of the usual type is introduced into a rubber tray of internal width 2 ft. and internal depth 1 in. and is adjusted to a uniform thickness of 1 in. by means of a scraper blade The tray bearing the latex is then passed between the electrodes at the rate of 4 in. per minute. The frothed latex, as it leaves the electrodes, is completely gelled throughout, the temperature having been raised to about 70° C. Uniform heating throughout the dispersion is assured, and the froth structure is unimpaired. The gelled product is vulcanised, dried, and stripped by the usual methods[31].

2. Hot Vulcanisation of Rubber Goods

Although in many cases no practical advantages might accrue, there seems to be no objection in principle to the application of capacity-current heating to all hot vulcanisations, with the possible exception of that of electrically conducting rubbers. The literature carries mention of many specific articles, including pneumatic and solid tyres[3, 20], belting[20], manufacture and repair of cables[3, 11, 16, 17, 18, 19, 20, 25, 27, 32, 33, 34, 35], printing and similar rubber-covered rolls[3, 15, 20, 23], packings[20], bonded abrasives[5], rubber road blocks[22], rubber flooring[20], sheeting[3, 20, 23, 27], sponge rubber[20], thermal reclaiming of scrap rubber[24], and microporous hard rubber from ebonite dust[14].

Cables—For some years the continuous vulcanisation of insulated wire and cable has made much progress, and high-frequency heating lends itself very readily to this particular operation. All the references to cable manufacture discussed here relate to the continuous process. The pioneers were Dufour and Leduc who, in 1935, applied for letters patent in respect of continuously vulcanising a

*Research Association of British Rubber Manufacturers.

Fig. 1. I
Fig. 3 (b

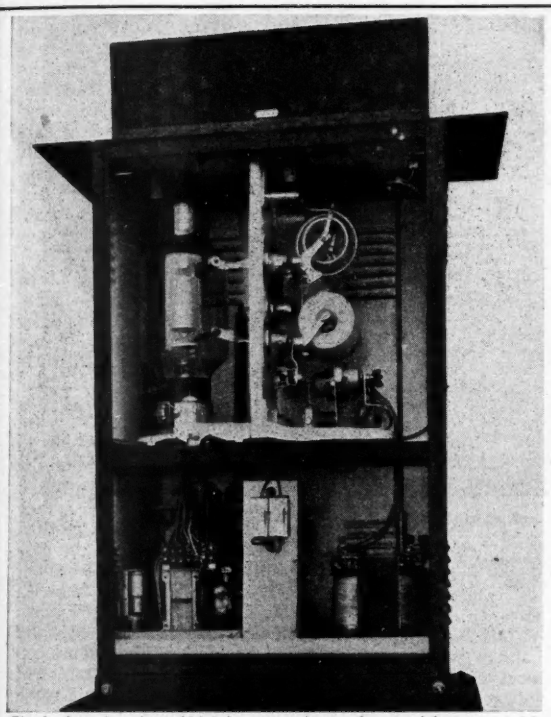


Fig. 1. Interior view of high frequency heater for repairing p.v.c. cables.

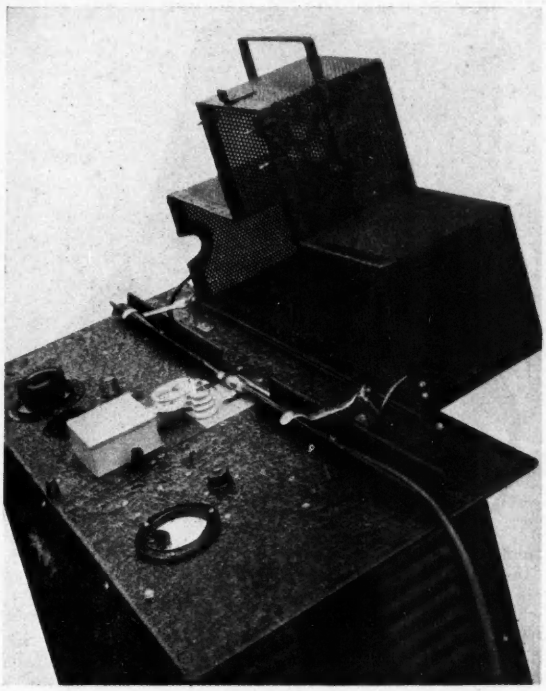


Fig. 2. Close up of high frequency heater for repairing p.v.c. cables.

Fig. 3 (bottom left). Vulcanisation on a rotating drum between fixed electrodes.

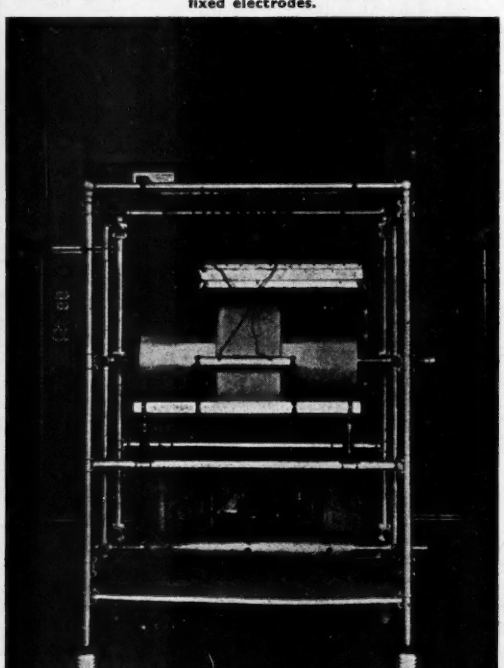
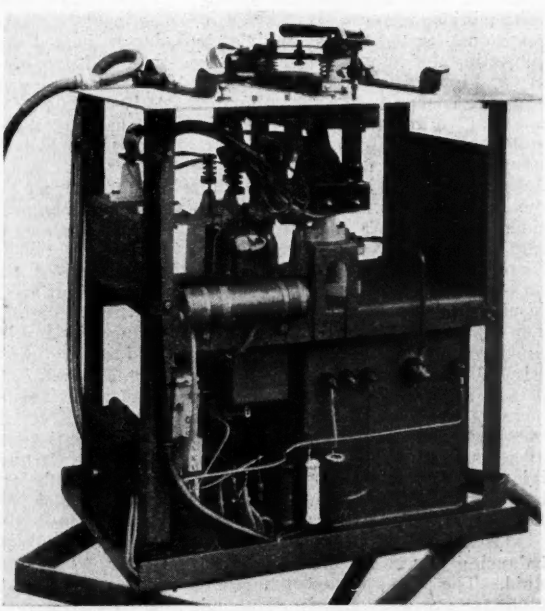


Fig. 4 (bottom right). Interior view of seam welder for plastic strip and sheet.



Note.—*Figure 3 is reproduced by courtesy of Messrs. W. Heffer & Sons, Ltd. : other photographs by courtesy of British Insulated Callender's Cables, Ltd.*

Fig. 5. Close up of seam welder for plastic strip and sheet.

By courtesy of British Insulated Callender's Cables, Ltd.

rubber composition on a metallic conductor by passing the latter past an electrode surrounding the rubber while exciting a high-frequency electric field between the conductor and the electrode to heat the rubber internally to vulcanising temperature[11]. Later the Okonite Company developed the process much further[1, 22, 32, 34, 35]. Long lengths of rubber, *e.g.*, insulated cable, are vulcanised by passing through a long column of liquid or of comminuted solids (*e.g.*, water, brine, mercury, lead oxide, or soapstone) and heat is applied by subjecting the column to the influence of a high-frequency electric field. Pressure is supplied by the column of material, eliminating the need for stuffing boxes. In applying a composite sheath to the material to be heated-treated and an outer flexible metal layer, the assembly is led continuously through a chamber containing fluid under pressure and high-frequency heat is induced in the layer to be heat-treated. Again, rubber-insulated electric cable is vulcanised continuously by passage through a pressure chamber containing an electrically conductive liquid such as brine, or graphite dispersed in a heavy grease, and heating by means of a high-frequency electric field. To avoid deforming the insulation at the inlet and outlet glands the stuffing boxes are not made with a leakproof fit, but air conduits lead into both glands and maintain an air pressure balancing that of the conducting fluid. The pressure used may rise as high as several hundreds of pounds to the sq. in.

Inventors associated with British Insulated Cables, Ltd. encountered difficulty in certain cables vulcanised by the high-frequency method, and employed ingenious means to get over it. In a continuous process involving subjecting the material to a high-frequency electric field between an external tubular electrode or a succession of such electrodes placed end to end, and the wire[18], it was found that when two layers of rubber of different conductivities were to be vulcanised the insulating layer adjacent the conductor heated up far more rapidly than did the outer abrasion-resistant layer consisting of relatively electrically-conducting rubber. This was because the major fall in potential occurred across the highly insulating rubber, the conducting layer not being able to support a high potential difference and therefore heating but slowly. In order to secure uniform vulcanisation in the two layers, the rubber to be vulcanised is carried through a short cylindrical coil to the terminals of which a high-frequency alternating voltage is applied so that the coil produces within it a high-frequency magnetic field. Within this field the conductivity loaded rubber provides a closed turn of a transformer within which heat is generated by the passage of the high-frequency currents. Frequencies of the order of 102-200 Mc/s. are preferred, and the rubber may pass through a succession of coils. Gas pressure may be applied to the rubber, which enters the device via a rubber gland[17].

Mechanicals. — The very long periods of time necessary to obtain reasonably uniform vulcanisation of large rubber-covered rollers was one of the instances chosen by Leduc to illustrate the advantages of high-frequency heating[3, 15, 20, 23]. He suggested that first of all the metal core should be heated by means of currents induced in it by an alternating magnetic field, which would leave the rubber unaffected, and then the rubber vulcanised by the high-frequency alternating electric field.

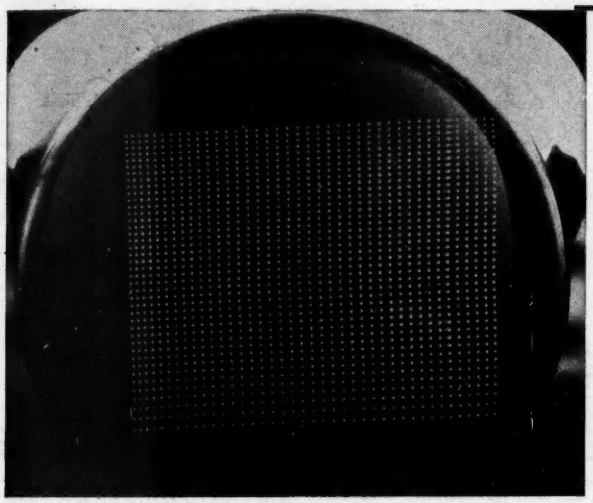
An interesting point is made by the Carborundum Co. in a patent specification covering the application of high-frequency vulcanisation to rubber-bonded abrasive manufacture. Pointing out firstly the great time saving that results (abrasive disks as small as 8 in. in diameter and ½ in. thick need vulcanisation up to 20 hours in duration, whereas using the high-frequency method the process can be completed in 25 minutes), they proceed to state that by this method the heat is generated more in the particles of abrasive than in the rubber with the result that rubber immediately adjacent the particles of abrasive is more fully vulcanised, and therefore harder, than that comparatively remote. This has the effect of anchoring each abrasive particle more firmly in the matrix than is the case when the latter is uniformly soft and the article has a much longer useful life[3, 29, 30].

Road blocks, ordinarily taking 2½ hours to vulcanise, can now be completed in 5-6 min. by the new method[23].

Sheeting.—Leduc believes that capacity-current heating methods can be applied to any article which can be vulcanised in long lengths in roll form, *e.g.*, belting, rubberised fabric, and flooring[3, 20, 23, 37]. For example, he states that 1,000 metres of fabric can be wound on a roll 1 metre in diameter, in which case the roll of material will be 20 cm. thick. Such an assembly can easily be heated by high-frequency methods and temperature differences in different parts of the mass will not vary by more than 1°-2° C.

Sponge.—Again, the advantages of reduced period of vulcanisation and uniformity of heating are in evidence, sponge rubber being a very poor conductor of heat. Leduc[20] divided a sponge rubber mixture into two parts, one being vulcanised by the ordinary methods and requiring a period of 200 minutes and the other treated by high-frequency methods, vulcanisation in the latter case being completed in 35 minutes.

(*Continued on p.* 276.)



Dot pattern on tube screen for checking linearity of sweep.

C. R. Tube Quality Measuring Apparatus

By A. M. SPOONER, B.Sc.*

A paper read before the Television Society on January 1, 1946

DISTORTION in a television receiver may be divided into two parts, that due to all the circuits up to the grid of the picture tube and that due to the time bases and picture tube itself. It is with the latter part that this paper is concerned, and the apparatus to be described was developed for the measurement of distortions occurring in both magnetically and electrostatically deflected tubes (including oscilloscope tubes) and their associated time bases.

The apparatus generates pulses (synchronised to the line and frame frequencies) which are fed to the picture tube grid to produce on the screen a grid of dots. Any departure from a truly rectangular raster in which the dots are equally focused and equally spaced, both horizontally and vertically, indicates the presence of one or other of the following faults: (a) line time base non-linearity, (b) frame time base non-linearity, (c) barrel or pincushion distortion due to deflection system (coils or plates), (d) deflection defocusing. In addition, the variation of spot size with peak beam current may be determined without overloading the screen as would occur if the deflection systems were disconnected and the stationary spot in the middle of the screen were examined.

Requirements of Circuit

To obtain a grid of dots on the screen it is necessary to employ three waveforms, *viz.*:—

(a) Very short duration pulses having a repetition frequency some convenient multiple of line frequency to give chosen number of dots per line.

(b) Flat-topped pulses lasting for the duration of one line and having a repetition frequency some convenient multiple of frame frequency to give a chosen number of lines visible per frame.

(c) Combined line and frame blanking signal to eliminate flyback lines which would appear as spurious dots. (This may be provided by a television signal generator.)

These three voltage waveforms are added together by three valves having a common anode resistor. Systems in which the combination of two waveforms is effected by applying one signal to the first and the other to the third grid of a pentode suffer from the difficulty that if either is driven to its cut-off point, the other loses control.

The pulses at a multiple of line frequency may be obtained simply by synchronising a multi-vibrator running at a multiple of line frequency by means of line frequency pulses from the same signal generator that supplies the blanking signal, the number of dots per line so derived being variable continuously and stably over a wide range. There are, however, distinct limitations on the number of horizontal lines of dots that may be obtained by means of pulses at a multiple of frame frequency due to the requirements imposed by interlacing. To obtain a stable pattern of horizontal lines, the even lines visible on the screen must be supplied during the first traversal of the screen, and the odd lines, during the second (interlaced) traversal, or *vice versa*, while the second set of lines must fit exactly into the gaps left by the first set, otherwise the pattern will move up or down the screen.

For a system having N total lines, taken in groups of n (*e.g.*, n lines, including flyback, visible on the screen), and if m is any whole number, it may easily be shown that:—

$$n = \frac{N}{2m - 1}$$

Taking values of m from unity upwards, putting $N = 405$, and discarding results for which n is not a whole number, the possible values which n may take are:—

405, 135, 81, 45, 27, 15, 9, 5, 3, 1.

Since the range is so restricted, it was decided to confine adjustments around one of these possible numbers of horizontal lines, 27 being chosen in this case.

The dots produced on the screen must appear truly circular over a range of screen brightness from zero up to the point where the size appears several times bigger due to halation. It is necessary that the duration of the top of the voltage pulse causing the dot shall be considerably less than the duration of one picture element;

*Mullard Radio Valve Co., Ltd.

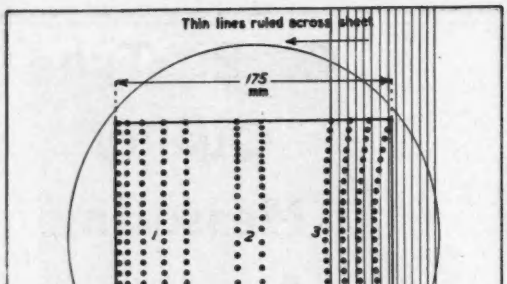


Fig. 2. Various dot patterns showing distortion in scanning: 1. Non-linear line time base. 2. Non-linear frame time base. 3. Pin cushion distortion.

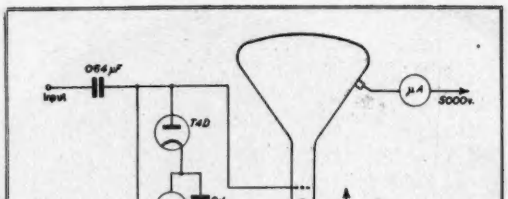
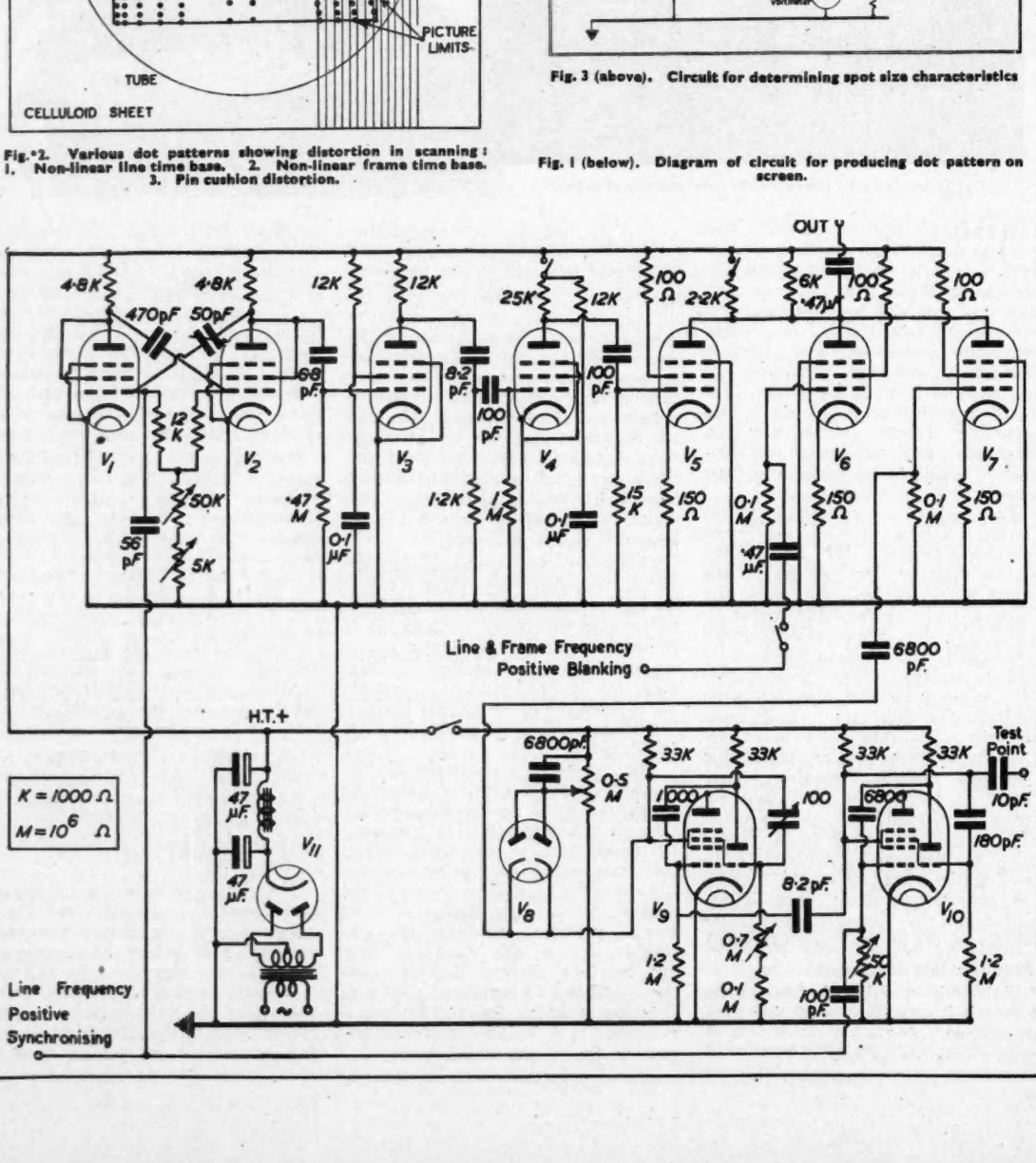


Fig. 3 (above). Circuit for determining spot size characteristics

Fig. 1 (below). Diagram of circuit for producing dot pattern on screen.



the latter corresponding to a time of :—

$$T = \frac{1}{25} \times \frac{1}{(405)^2} \times \frac{4}{5} \text{ secs.}$$
$$= 0.195 \ \mu\text{sec.}$$

for an aspect ratio of 4 : 5.

Description of Circuit

Referring to the circuit diagram (Fig. 1), V_1 and V_2 form an unsymmetrical multi-vibrator which runs at a frequency between about 10 and 50 times line frequency. The frequency of operation is controlled mainly by the small variable condenser connecting the grid of V_1 with the anode of V_2 and also by the variable resistance common to both grid circuits. The multi-vibrator is synchronised by positive line frequency pulses taken from a television signal generator synchronised in turn from the mains.

The signal is amplified by V_3, whose anode circuit contains a condenser and resistance having a time constant short compared with the duration of the pulse. The voltage appearing across the resistance has a very steep front and a rather less steep decay curve.

The section of the circuit concerned with the production of the signal at a multiple of frame frequency consists of valves V_7, V_8, V_9, and V_{10}, and their associated components. Line frequency pulses are fed from the signal generator into V_{10}, which is a triode hexode working as a multi-vibrator; the frequency adjustment being the 50,000 ohm potentiometer, connected between earth and grid 1 of its hexode. The test point brought out from the valve is used for setting up; adjustment is made using an oscillograph so that the multi-vibrator runs at 1/3 of line frequency. By making V_9, the second multi-vibrator, run at 1/5 of the frequency of V_{10} (*i.e.*, 1/15 of line frequency), we may obtain a pulse every 405/15 lines, *i.e.*, every 27 lines. The pulse fed from the grids 2 and 4 of V_9 is a negative one; according to the adjustment of the H.T. potential fed to the anode of the diode V_8, so more or less of the top of this pulse will be cut off, leaving a flat top. Mutual adjustment of this potential, together with the variable condenser and resistance associated with the second multi-vibrator V_9, gives a flat pulse of length one line or slightly more, and of the correct frequency to give 27 lines on the screen.

Switches are provided for the different sections so that either vertical or horizontal lines may be produced, closure of both switches resulting in a grid of dots. The fly-back may then be suppressed by closing the switch through which the combined frame and line blanking signal is fed to V_6. The valves V_3, V_6 and V_7 have a common anode resistor and so add the three waveforms. A further switch is provided which puts a lower resistance in parallel with that already in the anode circuit for convenience in certain applications.

Use of Apparatus with Mullard Magnetically Deflected Television Picture Tube Type MW 22-1

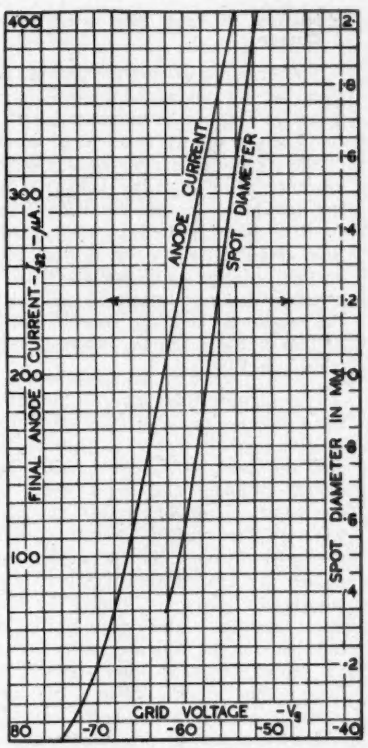
The picture tube is mounted in a wooden frame, across the front of which is fixed a sheet of celluloid on which are scratched thin vertical lines at half-centimetre intervals, and are used to assess line or frame deflection linearity, and pin cushion or barrel distortion. (Fig. 2.)

(a) *Line time base non-linearity* appears as a non-uniformity of spacing of the vertical lines. If the number of vertical lines of dots produced is adjusted until coincidence is obtained at one side of the screen between the ruled lines on the celluloid and the lines on the screen, then displacement will occur between lines on the screen and ruled lines over the rest of the screen. The percentage non-linearity may be estimated by dividing the maximum displacement by the line amplitude on the screen. (1, Fig. 2.)

(b) *Frame time base non-linearity* appears as a non-uniformity of spacing of the horizontal lines, and its value may be measured by turning the celluloid sheet of ruled lines through 90°, or more simply, in the case of the magnetically deflected tube, the coil system may be turned through 90°. The number of lines is fixed at 27 so that in this case adjustment for coincidence of the lines must be accomplished by slight adjustment to the amplitude of the frame time base. (2, Fig. 2.)

(c) *Barrel or pincushion distortion* may be observed by noting if the figure of the screen is a true rectangle, and if not, measuring the deviation from straightness of the outer lines of dots. (3, Fig. 2.)

(d) *Deflection defocusing* may be observed by comparing the size of dots near the centre of the pattern with those at the edge.



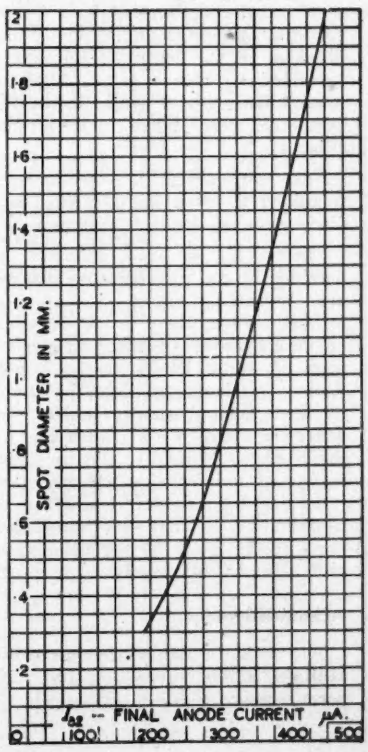


Fig. 4 (Col. iii, top). Beam current characteristics.
Fig. 5 (bottom). Spot diameter/beam current characteristic.

Variation of Spot Size with Beam Current

The circuit used for the determination of the above characteristic is given in Fig. 3. A microammeter in the 5,000 V supply to the final anode of the picture tube indicates the beam current, while a valve voltmeter in the cathode circuit indicates the positive bias applied to the picture tube cathode. With the control grid earthed, giving a uniform raster, *i.e.*, constant beam current, variation of the brightness control gives the curve of bias voltage against beam current shown in Fig. 4.

The picture tube may be supplied from the quality measuring apparatus to give a grid of dots on the screen, and the peak voltage occurring between cathode and grid read by means of the diode circuit shown in Fig. 3. The positive pulses forming the grid of dots on the screen are passed by the diode and their D.C. component gives a reading on the microammeter. By adjustment of the backing-off voltage to a value at which current just ceases to flow, the peak value of the voltage occurring between cathode and grid of the picture tube may be read on the voltmeter V_b. Corresponding readings of V_b and spot diameter at the centre of the screen (obtained by means of a travelling microscope with a graticule in the eyepiece) were taken and plotted (Fig. 4).

The two curves in Fig. 4 were combined to give Fig. 5, the spot diameter/beam current characteristic.

The values of spot diameter as obtained by the travelling microscope are subject to sources of error as follows. First, there is the difficulty of measurement of the diameter of spot of light which is not quite stationary (due to random variations in the 5,000 V supply and/or the deflection circuits) and which has no sharp edge. Secondly, the optimum setting of the focus is not quite the same for high as for low level of illumination. The readings taken are with the focus set for optimum at high illumination levels.

Acknowledgment

The author's thanks are due to the Mullard Radio Valve Co., Ltd., for permission to publish this article.

Capacity-current Heating in the Rubber Industry

(*Continued from p. 272.*)

The Expanded Rubber Co. proposes[12] to prepare cellular rubber by using adsorptive carbon to introduce the blowing agent. The carbon is freed from adsorbed gases by exposure to vacuum and then is exposed to an inert gas such as helium, nitrogen, or carbon dioxide. It is compounded into the rubber stock which is then heated by exposure to the high-frequency field. It is claimed that both sponging and vulcanisation are uniform.

Jacobs states[14] that microporous rubber of very low conductivity can be made easily from ebonite dust by the high-frequency technique whereas it is a difficult operation using methods normally at the disposal of the industry.

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TELEVISION COMMENTARY

THE O.B. Unit, winning on weather, has provided first-rate points against the month's programmes; the Motor Jubilee Cavalcade (July 27); the Open Air Theatre (July 14); Speedway Racing (July 20); the International Athletic Meeting (August 5), among others. These two stadium broadcasts, similar in scale, showed all the difference between success and failure. Following the runners on the big track at the White City and catching the high jump at the right moment were achieved by nimble camera work, and, in spite of a breakdown, interest was high; the poor light at Wimbledon did not entirely account for television's failure to convey to viewers, comfortably seated at home, the breathless thrill which draws crowds to the speedway. The former was "telegenic," the latter attempted the impossible.

Two theatre relays, Beatrice Lillie in "Better Late" (July 15) and Arthur Askey in "Follow the Girls" (August 12) were welcome reminders that artistes play so much better to their accustomed audiences than to the studio engineers, that sound and lighting problems—rather pronounced in "Better Late"—can be forgotten by viewers who can join in the laughs of a well-filled auditorium. In O.B.s and in the studio, producers seem anxious to abandon a good shot in a hurry in favour of camera changes for the sake of change. To hold a good angle as long as possible rather than change as frequently as possible would seem a good rule. And superimposed images, so effective when there is an adequate dramatic motive, are working rather hard at present.

Viewers enquire whether their devotion to television has ruined their next year's fruit. Mr. Streeter's persuasive advice is not clear pictorially. When one gets down to the serious business of pruning, lack of colour and fine detail is a pitfall for novice gardeners. The criticism applies also to even the choicest display of flowers. We cannot yet hope for perfume by radio, but what is a rose in black and white?

How well Mr. E. R. Voigt puts across the boxing and wrestling programmes. But their frequency almost amounts to propaganda. Is the B.B.C. trying to educate for muscle? This is hardly fair during bread rationing.

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R.F. AMPLIFIER TETRODE

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V_a ..... 300 V.
I_a ..... 42.5 mA.
W_{out} 6.0 W.
Frequency 150 mc/s.

V_f ..... 6.3 V.
I_f ..... 0.6 A.
Max. overall length 78 mm.
Max. diameter 38 mm.

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Technical data and advice, on the applications of the QVO4-7 and other transmitting and industrial valves, can be obtained from THE MULLARD WIRELESS SERVICE CO. LTD., TRANSMITTING & INDUSTRIAL DIVISION (TECHNICAL SERVICE DEPT.), CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2.

(139)

A New Electrometer Valve

By J. A. Darbyshire, Ph.D., F.Inst.P.*

SPECIAL valve circuits for the measurement of very small currents (of the order 10^{-15} amperes) have been described by many workers, notably Brentano, Wynn Williams and DuBridge.

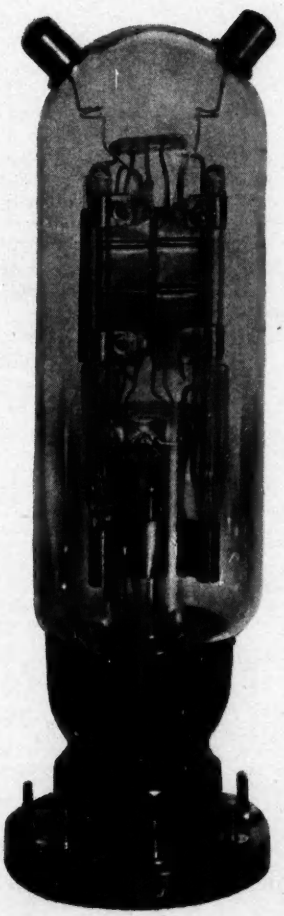
These circuits have been designed to operate with electronic valves of special design, such as the FP54 manufactured by the General Electric Co. The FP54 is a tetrode having a control grid which is highly insulated in order to reduce grid leakage to a minimum. The filament rating is 2.5 volts, 90 milliamperes and it is surrounded by a grid of fairly close pitch which is operated at a slight positive potential. This screen grid is inserted to reduce any tendency for positive ions to reach the negative control grid from the filament. The screen is usually operated at a potential below 6 volts and the anode at a potential below 8 volts in order to avoid any ionisation of the residual gas in the tube. The grid input current can thus be reduced to a value as low as 10^{-15} amperes.

This valve is often used in a neutralised bridge circuit as introduced by DuBridge and Brown[4].

The use of a balanced bridge circuit using two valves was first described by Brentano[1] in 1921. This was followed by a description of a similar circuit by Wynn Williams[2] in 1927 and by DuBridge[3] in 1931, and later on DuBridge and Brown[4] described a new circuit in which only one valve was employed. In this circuit one arm of the bridge consisted of the filament to screen impedance, and the other arm consisted of the filament to anode impedance. This circuit had certain advantages over the double-valve circuit because the emission for both sections came from one and the same source. The authors described how to adjust the circuit controls so that, in the first order, the balance was affected by variation of the voltage of the supply or changes in emission of the filament.

In his later paper in 1939, Dr. Brentano[5] pointed out that the single-valve circuit was asymmetrical and would be disturbed more readily by the influence of stray fields. Brentano agreed that the use of a tetrode with a single filament minimised the fluctuations due to variation in emission characteristics in the two valves and, to retain this feature, he described the use of a new double-triode valve in which the two triode sections obtained their electrons from a single cathode.

A small number of these double-triode valves were made up by Ferranti, Ltd., in 1938, at the request of Brentano and they were found to have some considerable advantages as regards stability, especially when compared with the original double-valve circuit. The control grids of these original double-triode valves were not insulated up to the true standard characteristic of the electrometer valve technique and the new tube which is now being developed by Ferranti, Ltd., is a double tetrode in which each section has a characteristic similar to that of a single tetrode of type FP54. The two control grids are both highly insulated in accordance with electrometer valve requirements.



A photograph of this tube is shown in the figure.

A small number of these tubes have been constructed in this laboratory, and at the time of writing the characteristics are as follows:

Filament: 2 volts, 90 mA.

Screen voltage: 6.

Anode voltage: 8.

Anode current at zero bias: 300 microamperes.

Cut-off: -12 volts.

Mutual conductance: 25 μA/volt.

Control grid capacity approx.: 7 $\mu\mu$fd.

Control grid input current at $V_g = -3$: not more than 10^{-15} amperes.

A single tetrode similar to the FP54 is also being developed. This tube is being operated in a neutralised circuit of the DuBridge and Brown type, and the double tetrode is being operated in a circuit of appropriate design.

The fluctuations observed in these two types of circuit under various conditions of interference are under observation, and it is hoped to publish details later.

* Physical Laboratory, Ferranti, Ltd.

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Fundamental Tone Control

THIS reference sheet is devoted to methods of obtaining the four chief types of tone control, namely, "top cut," "top lift," "bass cut" and "bass lift." The circuits described will use resistors and capacitors only, so no tuned circuits are employed. The types of frequency response given by simple resistance-capacitance networks generally are illustrated in Fig. 1 opposite. Curve ABC may represent either top lift (if the portion AB is arranged to cover the audio-frequency spectrum) or bass cut if the point B is made to coincide with a very low frequency such as 30 c/s. Similarly, curve DBE may represent top cut or bass lift, depending whether portion DB or BE is used.

Basic Circuits

Two simple circuits giving the frequency responses pictured in Fig. 1 are given in Figs. 2 and 3. It is the ratio of the reactance of C_1 to the value of R_2, which decides what portion of the curves is obtained. For example, in Fig. 2, if X_{c1} is made equal to R_2 at about 200 c/s., then bass lift results, and in Fig. 3 if X_{c1} equals R_2 at 200 c/s., then bass cut is obtained. Two limiting cases of these two circuits are of interest: if R_2 is omitted (equivalent to making $R_2 = 0$) in Fig. 2 then top cut results; if R_2 is omitted in Fig. 3 (equivalent to making its value approach infinity) bass cut results.

Practical Circuit Diagrams

Practical circuit diagrams based on Figs. 2 and 3 are given in Figs. 4 and 5 respectively. Load resistors (R_1), coupled capacitors (C_c) and grid leaks (R_{gl}) have been introduced where necessary. Some suitable component values are listed below (in these the tone-control circuit is taken as being effective from that frequency at which it affects the response by 1 db.).

It is possible to combine the circuits of Figs. 2 and 3 into a single intervalve circuit giving, for example, bass lift and top lift simultaneously. Such a circuit is given in Fig. 6, and the component values given are suitable for a 12 db. lift at 30 c/s. and 10,000 c/s. Similarly, a circuit based on Figs. 2 and 3 could be developed to give combined top cut and bass cut.

Tone Control by Negative Feedback

Tone control may also be achieved by including the networks of Figs. 2 and 3 in the negative feedback chain of an amplifier, but the type of frequency response given by the circuit in these conditions is different from that given by it in the form given in Figs. 4 and 5. For example, if the network of Fig. 3 is connected up as shown in Fig. 7, where it is situated in the negative feedback chain, then the frequency response obtained will be that indicated by curve DBE in Fig. 1. R_1 is part of the tone control circuit and also functions as the automatic bias resistor for V_1. Top cut results if X_{c1} is made equal to R_2 at a high audio-frequency and bass lift if this condition is obeyed at a low audio-frequency.* Condenser C_2 is included to break the D.C. path between the anode of V_2 and the cathode of V_1. Resistor R_3 is included to limit the amount of feedback occurring at very high audio-frequencies, at which the reactance of C_1 is negligible; this is a practical point and prevents the instability which sometimes occurs with large degrees of feedback at frequencies outside the normal pass-band of the amplifier.

Fig. 8 shows a practical circuit diagram in which the circuit of Fig. 2 has been embodied in the negative feedback drain of an amplifier.

As before, C_2 is to prevent a D.C. path across the H.T. supply, R_1, R_2 and C_1 are the tone control components and R_3 is the automatic bias resistor. Top lift can be obtained by omitting R_2 and making X_{c1} equal to R_2 at a high audio-frequency. If this condition is arranged to occur at a low audio-frequency then bass cut results, but it would be advantageous in this case to include R_2 in series with C_1. This has the effect of making the impedance of the circuit which shunts R_2 become constant as frequency rises, thus giving a constant degree of negative feedback at these higher frequencies.

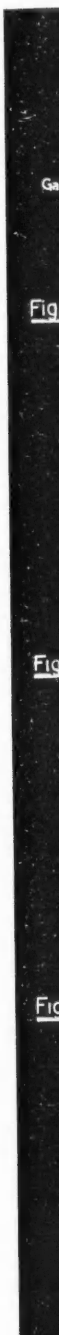
Variable Tone Control

To make the top cut or bass lift given by the circuit of Fig. 2 controllable a variable resistor can be connected in parallel with C_1. Its maximum value should be preferably at least five times the reactance of C_1 at the lowest frequency in which we are interested. In Fig. 3 a variable resistance should be connected in series with C_1 in order to control the amount of top lift or bass cut obtained and its maximum value should be at least five times the value of R_2. As an example of such a circuit Fig. 9 has been prepared. This embodies the fundamental circuit of Fig. 3 in the negative feedback chain of an amplifier to give "top cut." The 20,000 ohm. resistor, R_3, is to prevent excessive negative feedback and possible instability at very high frequencies and the 0.1 μF capacitor C_2 is a D.C. blocking component. This circuit gives a maximum top cut of about 12 db. at 10,000 c/s.

* A simpler method of obtaining bass lift is to omit R_2 and C_1 and make Xc_2 equal to $R_1 + R_2$, at a low audio-frequency, with perhaps a limiting resistance across it to prevent excessive feedback and possible instability at a very low frequency.

Details of Frequency Response	Fig. No.	Component Values
Bass lift, beginning at 300 c/s, rising 12 dbs 50 c/s	4	$R_L = 50{,}000\,\Omega$ $C_c = .01\mu F$ $R_1 = 250{,}000\,\Omega$ $R_2 = 50{,}000\,\Omega$ $C_1 = .015\mu F$ $R_{gl} = 1M\Omega$
Top cut beginning at 2,000 c/s, falling 12 dbs at 10,000 c/s at 10,000 c/s	4	$R_L = 50{,}000\,\Omega$ $C_c = .01\mu F$ $R_1 = 250{,}000\,\Omega$ R_2 omitted $C_1 = .002\mu F$ $R_{gl} = 1M\Omega$
Bass cut, beginning at 300 c/s, falling 11 dbs at 50 c/s	5	$R_L = 50{,}000\,\Omega$ C_c omitted $C_1 = .001\mu F$ R_2 omitted $R_1 = 1M\Omega$
Top lift, beginning at 2,000 c/s, rising 12 dbs at 10,000 c/s ..., ...	5	$R_L = 50{,}000\,\Omega$ $C_c = .02\mu F$ $C_1 = 100\mu\mu F$ $R_2 = .5M\Omega$ $R_1 = 0.1M\Omega$

Circ



Circuits — A Reference Sheet

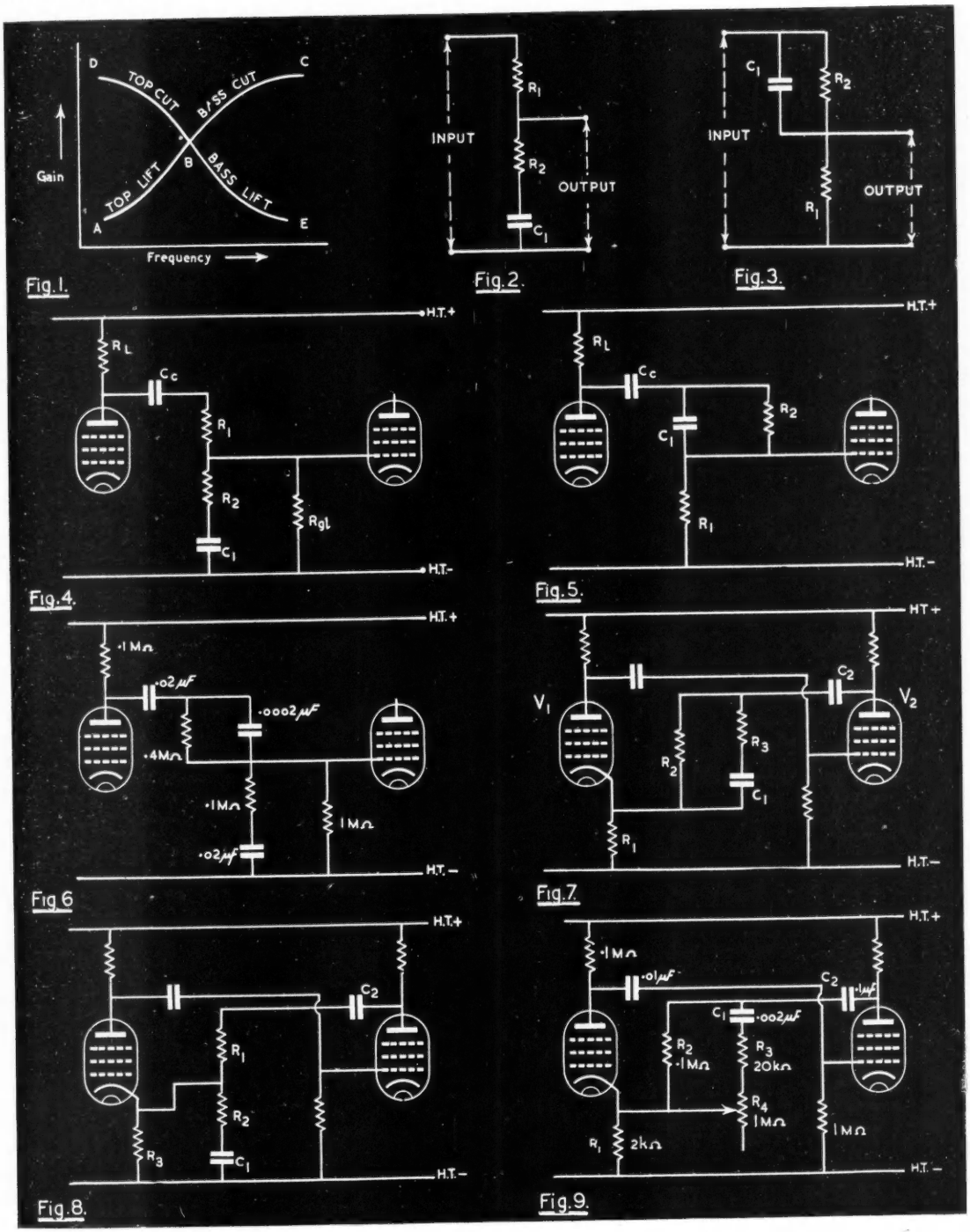


Fig. 1. Fig. 2. Fig. 3.

Fig. 4. Fig. 5.

Fig. 6 Fig. 7

Fig. 8. Fig. 9.

Plastics in the Electronic and High Frequency Industries

A Review of Available Synthetics

By WILLIAM S. PENN, B.Sc.

THE growth of the electronics and high frequency industries has been phenomenal. With this growth there has been a demand for more efficient insulants, which the plastics industry has strived to supply. It has succeeded to a great extent, and there are now several plastics available, which may be used with H.F. currents up to 10^8 c/s. and even higher.

However, some of the older plastics, which were at one time considered satisfactory, are now being replaced. Phenolic resins, for instance, are very limited in their scope, and even polystyrene has some faults. The object of this article is, therefore, to explain suitable insulants which are, or will be, available shortly, and point out the limitations of the old materials.

H.F. Insulant Theory

It is not intended to give a complex mathematical theory about high frequency dielectrics. The chemical differences influencing behaviour in H.F. fields will, however, be indicated. This will help in the correct choice of materials.

The greatest drawback to the use of a phenolic type plastic in H.F. applications is the large amount of heat developed. The quantity liberated per unit volume is given by the expression $f.C.E^2.\tan\delta 2\pi$ where f = frequency, C = capacitance, E = applied voltage and $\tan\delta$ = dielectric loss angle. This may be simplified to a constant x the product of power factor and dielectric constant. Consequently, the latter two factors should be kept as small as possible, and this should be aimed at in any choice of plastics for dielectrics.

Theoretically, if the molecules of an insulant are electrically (and this usually means chemically) asymmetrical they will oscillate and be distorted in an electric field. If this is due to a high frequency current, great frictional effects are set up due to the rapid movement of molecules and heat is developed. Molecules containing only hydrogen and carbon (polythene and polystyrene) are usually satisfactory and those containing oxygen, chlorine and nitrogen are generally unsatisfactory, although there are exceptions on both sides.

Plastics Compared

Before describing the H.F. insulants in detail, it would be well to compare all the present plastics to show those which are satisfactory and those which are not. Table 1 contains details of the product of dielectric constant and power factor for various plastics.

The first three plastics stand out far in front of the others, which are hardly satisfactory for H.F. work. The majority of plastics types may therefore be ignored for the purposes of this article with the possible exception of the mineral-filled phenolic. This type has been put on the market as an H.F. insulant and could be used with reasonable safety up to about 10^6 c/s. It has one great advantage and that is its ability to stand up to high temperatures.

Rigid Dielectrics

It is convenient to divide the plastics into two main types: first of all those which are used mainly for rigid mouldings and, secondly, those which are used for flexible applications such as cable sheaths.

Of the first type, the most commonly used at the present time is polystyrene. This is a clear thermoplastic which may be moulded, machined and the like. It has very good electrical properties, but has a fairly low softening point, often a big disadvantage. It also begins to lose its electrical properties at fairly low temperatures (70° C.). It is clearly desirable, therefore, to design plastics superior to this. Table 2 gives details of the properties of polystyrene, together with those of other plastics designed to overcome the troubles.

The first attempt to overcome the defects of polystyrene was by admixture with a plasticiser, chlorinated diphenyl. This raised the softening point by about 8° C. and the compound was termed Styramic. This was not sufficient, however, and polydichlorostyrene was evolved. (Styramic H.T. in the above table). This had a greatly increased softening point (up to 115° C.) and was satisfactory for most purposes. The electrical properties of this plastic were also quite good. Closely allied with Styramic H.T. are the Cerex resins. They have a high softening point (the limit is determined by moulding difficulties), but the electrical properties are certainly not as good as those of polystyrene or Styramic H.T.

The electrical properties of the above materials are little better than those of polystyrene at elevated temperatures, but an improved dielectric will be described later.

Flexible H.F. Dielectrics

The primary flexible dielectric is, of course, polythene (Alkathene), but there are other possibilities for certain frequency bands. Polythene is used both for mouldings and as a cable insulant. It does suffer from various drawbacks from the processing point of view, but these do not concern this article, which deals with the properties only as a dielectric. Polythene has extremely good electrical properties and is noted for its flexibility, which is maintained at about − 40° C. Table 3 gives details of its properties, together with those of other materials including rubber for comparison purposes.

It will be seen that the properties of polythene are much better than those of rubber (and this includes synthetic rubbers) particularly as an H.F. insulant. P.I.B. (polyisobutylene) is quite good but is rarely used as such, and is usually mixed with polythene. The mixture of P.I.B. and cyclised rubber is fairly satisfac-

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TABLE 1

Dielectric Constant and Power Factor Product for Plastics

Plastic	Product	Plastic	Product
Polythene	0.00023	Cellulose butyrate ...	0.1410
Polystyrene	0.00026	Vinyl types	0.1720
Silicones	0.00028	Cellulose acetate ...	0.1935
Phenolics (mineral filler)	0.0250	Urea plastics	0.2890
Ethyl cellulose	0.0463	Phenolics (wood flour ...	
Acrylate type	0.0640	filler)	0.4410
Nylon	0.0792	Cellulose nitrate	0.5400

TABLE 2

Properties of Rigid Dielectrics

Property	Polystyrene	Styramic H.T.	Cerex Resins
Dielectric constant (60–10^6 c/s.)	2.5—2.6 up to 5×10^8 c/s)	2.62	2.74
Power factor (up to 75° C.) (60–10^6 c/s.)	0.0002–0.0004 (up to 5×10^8 c/s.)	0.0002	0.0024
Power factor (75° C. plus)	0.0009	—	—
Dielectric strength, 0.005 in. thick	3,500 V/m.	—	—
Dielectric strength, 0.125 in. thick	500-700 V/m.	—	510
Surface resistivity	10^{16} ohm/cm.[3]	—	—
Volume resistivity	10^{17}–10^{19} ohm/cm.[3]	—	—
Heat distortion, ° C. ...	77–80° C.	110°–115° C.	100° C. plus
Specific gravity	1.054–1.070	1.38	1.05–1.07

TABLE 3

Properties of Flexible Dielectrics

Property	Polythene	P.I.B.	Cyclised Rubber & P.I.B.	Rubber (Vulcanised)
Dielectric constant (up to 10^6 c/s.) ...	2.3	2.4	2.3–2.5	2.4–2.7
Power factor (up to 10^6 c/s.)	0.0002-0.0005	0.0002-0.0005	0.0005-0.001	0.004
Volume resistivity ohm/cm.[3]	10^{17}	10^{16}	10^{16}	10^{15}–10^{16}
Dielectric strength V/m.	600–1,000	400–500	600	500–700
Specific gravity	0.92–0.95	0.91–0.95	1.0	1.0–1.3

TABLE 4

Dielectric Properties of Silicones

Property	Value
Dielectric constant (20° C.) 60 c/s.	2.7–2.8
,, ,, (20° C.) 10^6 c/s.	2.8
Power factor 60 c/s.	0.0001 or less
,, ,, 10^7–10^8 c/s.	0.0001
,, ,, 10^8 c/s.	0.0002–0.0004
Dielectric Strength (100 mils)	250–300 V/m.
Volume resistivity, ohm/cm.[3] (20° C.)	10^{14}
,, ,, (200° C.)	10^{12}

tory, although it has certain mechanical defects. It may be used in many instances, however, and synthetic cyclised rubber may be substituted for the scarce natural rubber. Incidentally, polythene quickly oxidises in the air and the power factor rapidly increases to 0.001. This trouble may be avoided if 0.1 antioxidant is added. The possibility of flexible polystyrene also exists. This in the form of a tape is used to insulate cables.

High Temperature Insulant

No really high temperature H.F. insulant has so far been described. In fact, only one exists and this has been announced very recently. It is the silicone type of resin, and it has an extremely promising future. It can be used at temperatures of 200° C. for quite long periods and up to 300° C. for short periods. Moreover, electrical properties are maintained at quite high temperatures, and it can probably be used at the very highest possible frequencies. Details of the properties are given in Table 4.

Unfortunately, these resins are only available as varnishes at the moment, and not as moulding powders. It is expected, however, that they will become available in this form, and meanwhile they may be used as impregnants for making laminated boards.

Future Possibilities

The majority of the present H.F. dielectrics have been described, but there are several other possibilities. For instance, the use of different phenols in phenolic resins has possibilities. The use of *m*-5-xylenol instead of phenol reduces the power factor from 0.012 to 0.005 (*see* B.E.A.I.R.A. L/T. 89). The possibility also exists of using styrene in conjunction with the condensation of phenol and formaldehyde which considerably lowers the power factor and dielectric constant.

The Styraloys are already appearing and these consist of copolymers of styrene and butadiene. Styraloy 22 is now advertised and has fairly satisfactory properties. The fluorinated hydrocarbons are also in the offing, but no details have been released.

It is obvious, therefore, that the electronic and high frequency engineer has a large range of materials at his disposal and he should not be at a loss for suitable insulants. Seven have been described and others are on the way.

An Electronic Code Translator

By HORACE W. BABCOCK*

This article (slightly abbreviated) describes an equipment which will be of interest to owners of experimental receiving stations, and is reproduced by kind permission of *Electronics* (U.S.A.).

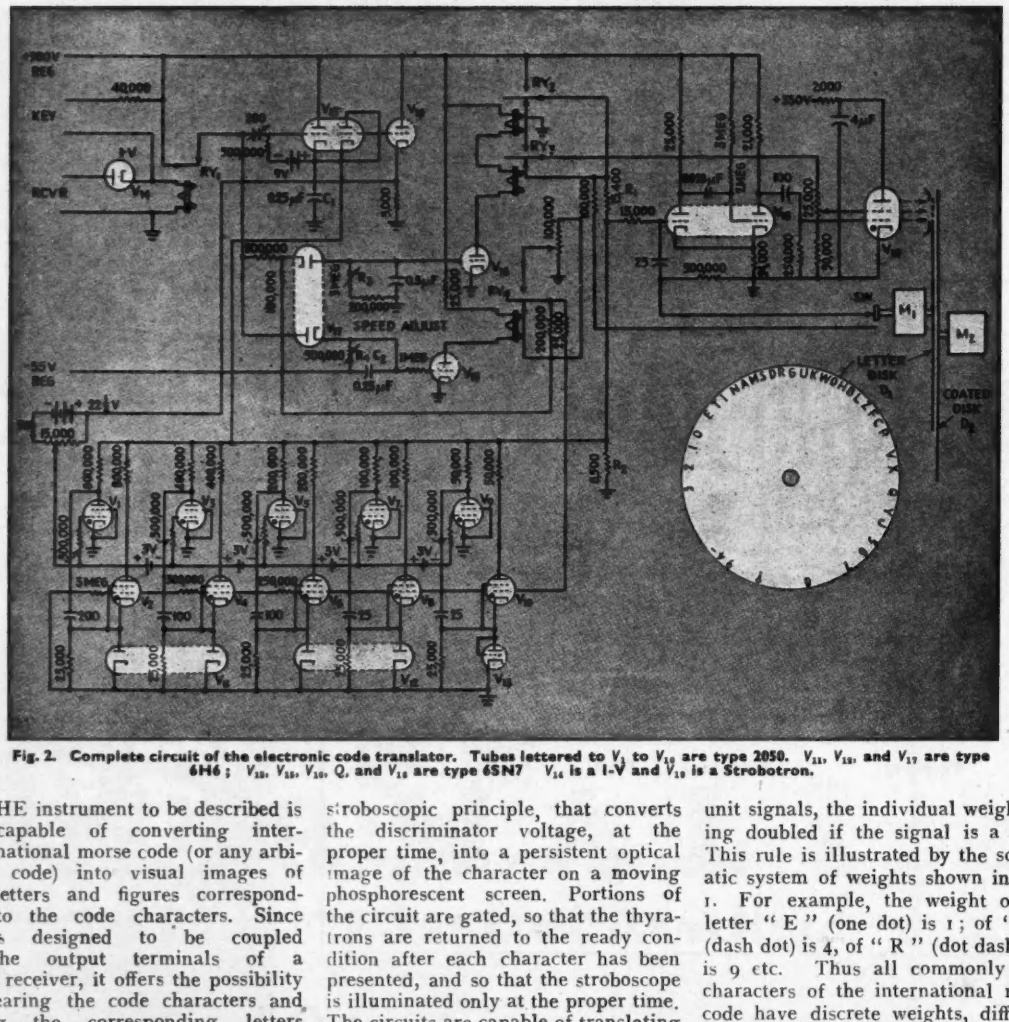


Fig. 2. Complete circuit of the electronic code translator. Tubes lettered to V_9 to V_{10} are type 2050. V_{11}, V_{13}, and V_{17} are type 6H6; V_{12}, V_{15}, V_{16}, Q, and V_{14} are type 6SN7 V_{14} is a I-V and V_{19} is a Strobotron.

THE instrument to be described is capable of converting international morse code (or any arbitrary code) into visual images of the letters and figures corresponding to the code characters. Since it is designed to be coupled to the output terminals of a radio receiver, it offers the possibility of hearing the code characters and seeing the corresponding letters simultaneously. Alternatively, code can be sent into the translator with a key for code instruction, as well as for communications.

The translator consists of two sections: (1) a discriminator, in which five or more pairs of thyratrons, employed as reset relays in a scaling circuit, produce after each group of dots and dashes a unique voltage determined by the character received; (2) an indicator, functioning on the stroboscopic principle, that converts the discriminator voltage, at the proper time, into a persistent optical image of the character on a moving phosphorescent screen. Portions of the circuit are gated, so that the thyratrons are returned to the ready condition after each character has been presented, and so that the stroboscope is illuminated only at the proper time. The circuits are capable of translating code at any speed that can be followed by a relay.

* Mount Wilson Observatory, Pasadena, California.

Weighted Characters

The code characters are analysed by the discriminator on the following basis. The dots and dashes in a character are considered as numbered 1, 2, 3, . . ., and the numbers are assigned weights in a geometric progression of 1, 2, 4, 8, etc. The total weight of each character is found by adding the weights of the individual unit signals, the individual weight being doubled if the signal is a dash. This rule is illustrated by the schematic system of weights shown in Fig. 1. For example, the weight of the letter "E" (one dot) is 1; of "N" (dash dot) is 4, of "R" (dot dash dot) is 9 etc. Thus all commonly used characters of the international morse code have discrete weights, differing in general by unity.

The heart of the discriminator is the array of five (or more) pairs of gas tetrodes (2050's or 2D21's) shown at lower left in the circuit diagram of Fig. 2. These valves represent the schematic arrangement of weights shown in the block diagram of Fig. 1, the weight being assigned to each valve by specifying its individual plate resistor.

When a given gas valve is turned on by a signal applied to its control

grid through the input network, it conducts a current that is nearly inversely proportional to the magnitude of its plate resistor.

The two valves of each pair have plate resistors of equal value, the valves decreasing in geometric progression to the right. Since all the individual plate resistors are coupled to a common point on a voltage divider between R_1 and R_2, and since the sum of all the tube currents passes through the common resistor R_1, the voltage drop across this resistor is determined by the particular group of valves that have been turned on. Thus, a unique voltage appears at the first grid of valve $V18$ in the indicator circuit, and this voltage corresponds to the particular letter or figure that was sent into the translator.

Circuit Analysis

The method of switching on the various dot and dash valves of the array may be followed by studying the circuit. The upper valve of each pair in the diagram ($V1$ . . . $V10$) is a dot valve, the lower is a dash tube. When a group of dots and dashes is introduced into the circuit, the dot valves are turned on, in order, at the conclusion of each unit signal, whether it be a dot or a dash. It will be noted that the successive dot valve grids are biased step-wise, and that the whole grid system is raised about three volts per signal by the intermittent charging of capacitor C_1, through the left-hand section of tube $V15$. (The right-hand section is used to discharge the capacitor when the circuit returns to the cleared condition.)

The problem of ensuring that the dash valve of a pair would go on at the end of a signal only if the signal was a dash was solved by placing two conditions on the ignition of each dash valve: (1) The corresponding dot valve must go on, giving a negative pulse to the cathode of the dash valve through capacitance coupling. (After ignition, diode anchor $V11$, $V12$ . . . prevents the thyratron cathode from rising appreciably in potential); (2) the grid of the dash valve must be at a sufficiently positive potential as determined by an RC circuit (R_4, C_2) that is controlled by the duration of the unit signal thus discriminating between dots and dashes.

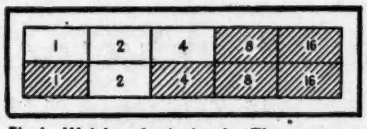


Fig. 1. Weights of unit signals. The upper row is used if the signal is a dot; the upper and lower rows are added if the signal is a dash. The total weight of the dots and dashes in a group is the weight of the character. The unshaded blocks show a total weight of nine for the letter 'R.'

At the conclusion of a group of dots and dashes, another RC circuit permits the indicator to function and then opens a relay ($RY2$) cutting off plate potential for all of the thyratrons and so extinguishing them. The circuit is then ready for the reception of the next code character.

The resistance elements (R_3, R_4) of the two timing circuits are ganged on a common control that is set by the operator with the aid of a calibrated dial to the approximate speed of the code being received.

The indicator section of the translator consists of the gate circuit associated with valve $V18$, a Strobotron or similar triggered-arc illuminating valve, and a stroboscopic letter disk carried on the rapidly rotating shaft of a 3,600-r.p.m. synchronous motor $M1$. The various letters and figures were punched out stencil-fashion around the edge of the disk in the order shown in Fig. 1.

The double triode $V18$ is connected in a biased multivibrator circuit† so that normally the left-hand triode is off and the right-hand triode is conducting. The circuit is tripped by a positive pulse on the left-hand grid. This pulse, or trigger, occurs at zero phase of rotation of the stroboscopic disk, upon the closing of a timer contact SW on the motor shaft. The duration of the interval during which the gate remains tripped is determined by the D.C. potential on the left-hand grid, and hence by the output voltage of the discriminator.

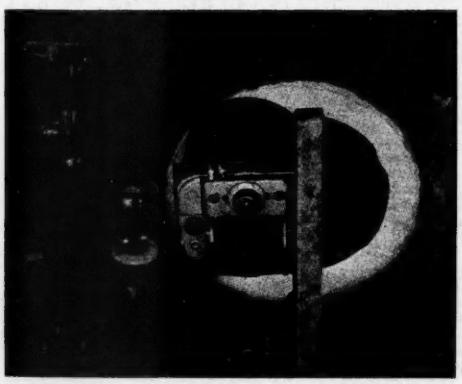
The Strobotron illuminating tube, $V19$, is triggered by the return of valve $V18$ to the stable condition, hence the illuminating flash occurs at a phase determined by the discriminator and the proper letter image appears to the viewer. The indicator valve is independently gated by the relay $RY3$, and hence is always off except for a brief interval at the termination of each code character. The gate is open long enough to permit illumination of the letter disk on two or more successive turns (several turns at low code speeds).

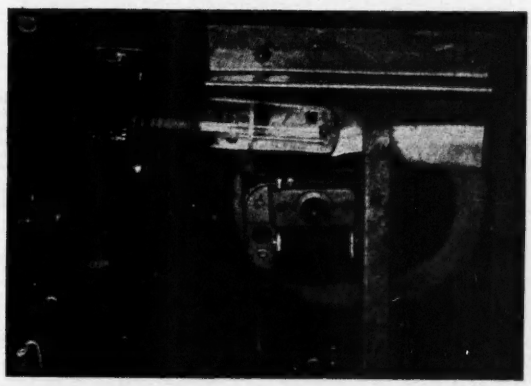
To facilitate reading, the illuminated letters are optically transferred from the stroboscopic letter disk to a slowly rotating glass disk, D_2, that has been coated with a sensitive phosphorescent compound. This viewing disk is rotated by motor $M2$ from right to left at a speed of one r.p.m. so that the letters of the message received appear in the proper sequence and their images persist for a number of seconds.

A working model of the translator has been built, and has given results both satisfactory and highly entertaining.

† This circuit is a variation of that given on page 59 in Puckle, O.S., *Time Bases*, John Wiley and Sons, Inc., 1943.

(Left). Tube and shield removed to show the placement of the letter-stencilled disk in relation to the phosphor-coated disk. (Right). The indicator tube is mounted behind the panel so that flashes shine through an aperture in the metal shield.





The Tapped Inductor Circuit

By J. E. HAWORTH, A.M.I.E.E.

THE tapped inductance in the tank circuit of a small power oscillator has often been considered as a simple impedance matching device, and its function is described in practically all radio engineering text books. In the following notes it is intended to show how a tapped inductor in conjunction with a suitable condenser can be considered as a two-terminal network possessing both resonant and anti-resonant features. By using a tapped inductor in the resonant circuits associated with valve oscillators and tuned amplifiers, the output waveform can be improved without the use of any additional circuit elements.

SYMBOLS USED

R_1 = H.F. resistance of L_1.
R_2 = H.F. resistance of L_2.
R = $R_1 + R_2$.
L = $L_1 + L_2 + 2M = L_2(1 + t^2 + 2kt)$.
M = $k\sqrt{L_1 L_2} = ktL_2$.
k = coefficient of coupling.
t = effective turns ratio = $\sqrt{L_1/L_2}$.
Q = $\omega L/R$.
ω = $2\pi \times$ frequency.
f_0 = resonant frequency of L and C.
n = f/f_0.
Z_n = impedance of Fig. 1 at frequency nf_0.
Z_{tn} = impedance of Fig. 2 at frequency nf_0.
Nf_0 = frequency at which Z_{tn} is a minimum.
j = $\sqrt{-1}$.
C = $1/\omega^2 L$.

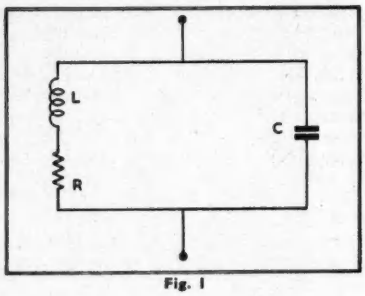


Fig. 1

Theory

Considering the circuit of Fig. 1, it can easily be shown that if the coil has a good power factor (say $Q > 50$) then

$$Z_n \approx \frac{Q\omega_0 L}{1 + jQn(1 - 1/n^2)} \quad \ldots\ldots\ldots\ldots (1)$$

For values of $n > 1.1$ this can be written:

$$Z_n \approx \frac{\omega_0 L}{n(1 - 1/n^2)} \quad \ldots\ldots\ldots\ldots (2)$$

From these two equations the normal resonance curve of Fig. 4 can be obtained. For convenience the function $20 \log_{10} Z_1/Z_n$ has been drawn, where Z_1 signifies the impedance when $n = 1$.

Considering now the circuit of Fig. 2:

$$i_1(R_1 + j\omega L_1) - j\omega M i_2 = i_2(R_2 + j\omega L_2 + 1/j\omega C) - j\omega M i_1$$

$$i_1(R_1 + j\omega L_1 + j\omega M) = i_2(R_2 + j\omega L_2 + j\omega M + 1/j\omega C)$$

hence $i = i_1 + i_2$

$$= i_1 \cdot \frac{R + j\omega L + 1/j\omega C}{R_2 + j\omega L_2 + j\omega M + 1/j\omega C} \quad (3)$$

$$= i_2 \cdot \frac{R + j\omega L + 1/j\omega C}{R_1 + j\omega L_1 + j\omega M} \quad \ldots\ldots\ldots (4)$$

As the voltage developed across the network is iZ_{tn}, then

$$iZ_{tn} = i_1(R_1 + j\omega L_1) - j\omega M i_2$$

and by substituting the appropriate values given in the text above it can be shown that:

$$Z_{tn} = \frac{\left[\begin{array}{l} R_1R_2 + \omega_0^2 t^2 L_2^2(1 - n^2 + t^2 + 2kt + n^2k^2). \\ \quad - j\omega_0 L_2 R_1 . 1/n.(1 - n^2 + t^2 + 2kt - n^2 t^2 R_2/R_1) \end{array}\right]}{R + jn\omega_0 L(1 - 1/n^2)} \quad \ldots (5)$$

As in the first case, if it is assumed that the coil has a good power factor, the terms containing R_1 and R_2 can be neglected and Equation (5) becomes:

$$Z_{tn} = \frac{\omega_0^2 t^2 L_2^2}{R + jn\omega_0 L(1 - 1/n^2)} . (1 - n^2 + t^2 + 2kt + n^2k^2) \quad \ldots\ldots\ldots (6)$$

and substituting $L = L_2(1 + t^2 + 2kt)$

$$Z_{tn} = Z_n \frac{t^2}{1 + t^2 + 2kt}\left[1 - \frac{n^2(1 - k^2)}{1 + t^2 + 2kt}\right] \ldots\ldots (7)$$

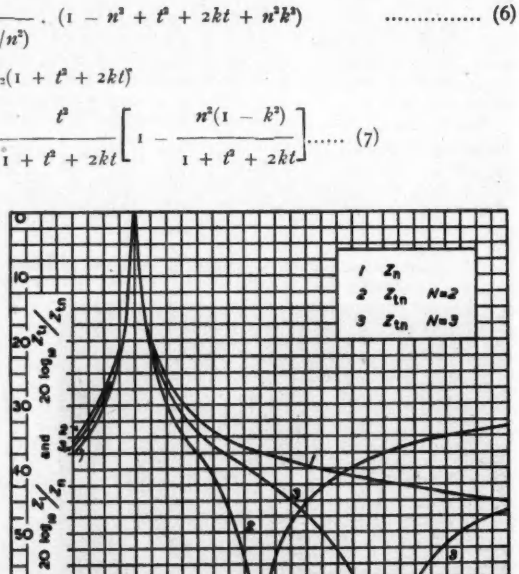


Fig. 4. Impedance characteristics showing resonant and anti-resonant effects.

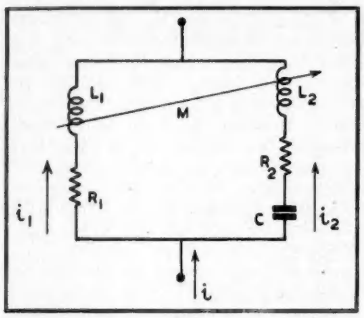


Fig. 2

From Equations (1) and (6) it will be seen that both Z_n and Z_{tn} will have a maximum value when $n = 1$, *i.e.*, at the resonant frequency of L and C.

From Equation (6) or (7), Z_{tn} will have a minimum value when

$$1 - n^2 + t^2 + 2kt + n^2k^2 = 0$$

and if it is desirable to make Z_{tn} a minimum at some particular frequency N_{to} then this becomes:

$$1 - N^2 + t^2 + 2kt + N^2k^2 = 0 \quad (8)$$

Hence if both N and k are known,

$$t = -k \pm \sqrt{(N^2 - 1)(1 - k^2)} \quad (9)$$

The negative sign is clearly inadmissible and there can be only one solution to Equation (9) in practice.

From Equation (8) $1 + t^2 + 2kt = N^2(1 - k^2)$ and if this is substituted in Equation (7) the impedance ratio can be written:

$$\frac{Z_{tn}}{Z_n} = \frac{t^2}{N^2(1 - k^2)}\left[1 - \frac{n^2}{N^2}\right] \quad \ldots\ldots\ldots (10)$$

The impedance ratio when $n = 1$ is usually the most important consideration, so if in Equation (10) $n = 1$ and the value of t is substituted from Equation (9) then

$$\frac{Z_{t1}}{Z_1} = \frac{N^2 - 1}{N^4}\left[\sqrt{N^2 - 1} - \frac{k}{\sqrt{1 - k}}\right] \quad (11)$$

These two equations show that the impedance ratio Z_{tn}/Z_n is quite independent of the circuit constants or the resonant frequency. Equation (11) shows that the impedance ratio Z_{t1}/Z_1 is entirely dependent on N and k.

The bracketed expression of Equation (10) is the only part of the equation containing the frequency term n and consequently the shape of the impedance characteristic is independent of t and k. Typical impedance characteristics are drawn in Fig. 4, where the function $20 \log_{10} Z_{t1}/Z_{tn}$ is shown. These characteristics clearly illustrate the resonant and anti-resonant effects.

The universal curves of Fig. 5 are probably more useful as they illustrate the frequency characteristic of the function

$$20 \log_{10} Z_{t1}/Z_{tn} \sim 20 \log_{10} Z_1/Z_n$$

$$= 20 \log_{10}\left|\frac{N^2 - 1}{N^2 - n^2}\right| \quad \ldots\ldots\ldots (12)$$

These curves are independent of t, k, and Q, and indicate the degree of improvement obtainable by using a tapped inductor as in Fig. 2 in place of the more conventional circuit of Fig. 1.

The curves of Fig. 6 have been computed from Equations (9) and (11) and illustrate the relationship between t, k and Z_{t1}/Z_1. It is usually desirable to suppress either the second or the third harmonic of the fundamental frequency and the curves of Fig. 6 supply all the information required for design purposes.

It is interesting to note that the theory is only valid for values of k less than some maximum value dependent on N. It is obvious that for a logical solution to Equation (9):

$$-k + \sqrt{(N^2 - 1)(1 - k^2)} > 0$$
$$\therefore k < \sqrt{1 - 1/N^2} \quad \ldots\ldots\ldots (13)$$

Applications

Perhaps the most useful application of the above theory is in the design of valve oscillators. The amplitude of oscillation is limited by the non-linearity of the maintaining system, which gives rise to an oscillatory current of non-sinusoidal waveform—indicating that the production of harmonics is a fundamental characteristic of any valve oscillator.[1] If this non-sinusoidal current is now passed through the network of Fig. 2, then by correct design of the inductor, it can be arranged that Z_{tn} is a minimum at any desired harmonic of the fundamental oscillatory frequency, thereby reducing the total harmonic content of the output waveform.

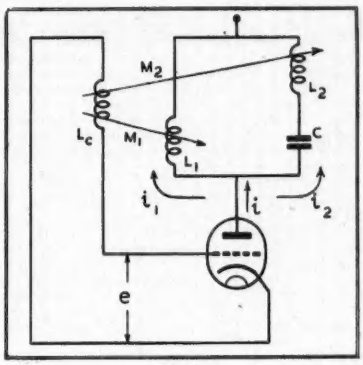


Fig. 3

A simple example is the tuned-anode oscillator shown in Fig. 3. To determine the condition for oscillation let

$$M_2 = k\sqrt{L_2L_c}$$

and $M_1 = k\sqrt{L_1L_c} = kt\sqrt{L_2L_c}$.

The grid voltage e is therefore given by $e = -j\omega M_1 i_1 + j\omega M_2 i_2$

$$= -j\omega k\sqrt{L_2L_c}(ti_1 - i_2)$$

By substituting for i_1 and i_2 from Equations (3) and (4), then

$$e \approx -\omega_o^2 ktL_2\sqrt{L_2L_c} \cdot i/R \cdot (t+1)(t+k)$$

But $i = eg_m$ where g_m is the effective mutual conductance, hence the condition for oscillation is:

$$-M_1 \geqslant \frac{R}{g_m\omega_o^2L_2(t+1)(t+k)}$$

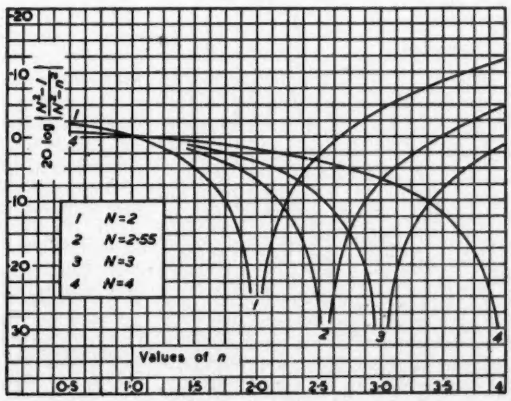


Fig. 5. Universal curves showing improvement obtainable by using tapped inductor in place of circuit of Fig. 1.

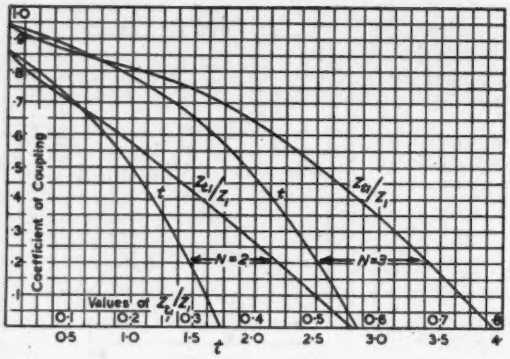


Fig. 6. Curves showing relation between effective turns ratio, coupling coefficient, and impedance ratio

For practical purposes this can be converted to the more useful form:

$$\sqrt{L_c} \geqslant \frac{1 + t^2 + 2kt}{g_m \omega_o Q k t \sqrt{L_2}(t+1)(t+k)} \quad \ldots\ldots\ldots\ldots (14)$$

The value of the coupling coil so calculated is greater than the value required if the inductor is not tapped.

In the case of a dynatron type of oscillator, a coupling coil is not required, but it is desirable to make the impedance of the resonant circuit comparable to the negative resistance of the valve.

Similarly, if a tuned circuit is required in the anode circuit of a power valve it is also desirable to match the impedance of the resonant circuit to the valve impedance if a maximum transfer of energy is required.

For any inductor the value of Z_1 can be determined and the optimum ratio Z_{t1}/Z_1 fixed. The optimum coupling coefficient k and turns ratio t can then be obtained from Fig. 6.

The application of this type of circuit to tuned amplifiers need not be treated in detail and it is sufficient to point out that in this case the value of N need not be an integer, but can be chosen so as to eliminate an interference frequency. The impedance ratio should be high—necessitating a low value of coupling—if a high-stage gain is required.

Conclusion

To conclude, a few practical details may be of interest. The curves of Fig. 5 indicate the improvement which is due entirely to tapping the inductor. The actual harmonic content at the output terminals of an oscillator designed on the above principles, however, may be lower than indicated by these curves for two reasons. Firstly, the lower impedance of the tapped circuit means a lower voltage swing and therefore the harmonics generated by the valve will be somewhat less, and secondly, the effective Q of a tapped circuit may be higher, depending on the method of winding. If a single layer coil is used, then tapping the coil has no effect on the Q, but if a banked winding is used for large values of inductance the Q may increase by 50 per cent. On the whole, therefore, the level of any harmonic at the output terminals can easily be reduced to less than 0.1 per cent. To achieve this, critical adjustment of L_1, L_2, and k, is not essential as quite an appreciable improvement can be obtained even if the actual harmonic resonance effect does not occur at the required frequency.

All the equations are independent of the value of the capacitor C, and consequently this type of circuit is also suitable for use where a variable condenser is required.

REFERENCE.

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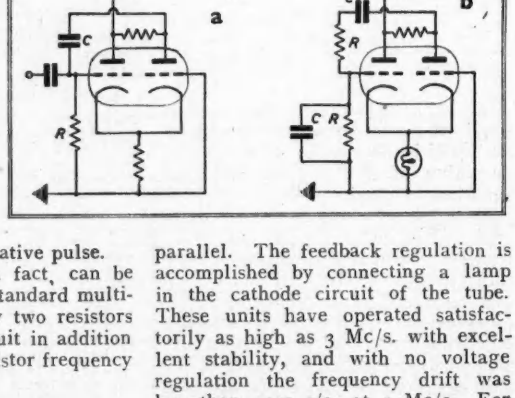
Two Novel Cathode-Follower Circuits

IN a paper to the I.R.E. on "The Cathode-Coupled Amplifier," K. A. PULLEN, junr., describes some novel circuits which he has tried experimentally, based on the wide-band characteristics which result from the high impedance input and the combination of the shielding feature of the impedance stabilisation resulting from the use of the grounded-grid amplifier.



Multivibrator

The circuit shown in the Figure (a) is the only simple form of multivibrator having identical waveform on both halves of the cycle. This results from the fact that at no time is the cathode current cut off as a result of the cathode follower, nor is either grid conducting at any time. The circuit has been used running free at 3-4 Mc/s., and a simple clipping stage will turn the output into a square wave. By biasing one grid to cut-off, the circuit can be made into a counter multivibrator, a differentiating circuit causing the counter to trip for each positive or negative pulse.

The arrangement, in fact, can be made to do all that a standard multivibrator will do. Only two resistors are required in the circuit in addition to the capacitor and resistor frequency determining circuit.

R.C. Oscillator

By modifying the multivibrator, an R.-C. audio frequency oscillator can be made by replacing the single resistor and capacitor by two resistors and two capacitors so arranged that one set is in series and the other in parallel. The feedback regulation is accomplished by connecting a lamp in the cathode circuit of the tube. These units have operated satisfactorily as high as 3 Mc/s. with excellent stability, and with no voltage regulation the frequency drift was less than 1000 c/s. at 1 Mc/s. For extending the range into the higher frequencies an additional cathode follower may be connected between the grounded-grid amplifier anode and the frequency-determining circuit.

—*Proc. I.R.E., June* 1946, *p.* 402.

Research and Development in Radio Technology

By R. A. COLLACOTT, Ph.D., B.Sc.(Eng.)

THE advance made in radio technology during the past half century has not been a matter of chance. It is the result of organised and enterprising industrial research.

Marconi based his original researches on the extension of the basic principles of science. Since this beginning of radio—as an offspring from "pure science"—each aspect of radio technology has been examined in every possible way, both experimentally and mathematically. From these researches it has been possible to trace the causes of other phenomena related to the problems of radio and means of expanding its performance; a review of these related "auxiliary" phenomena shows that, as with other technical subjects, they are also included generally within the scope of "pure science" and developed specifically to the solution of radio problems.

Planned Research

The radio industry is, in general, fortunate in that radio apparatus is not too expensive for even some of the smaller concerns to develop research laboratories. There are two ways in which these laboratories can be used, (a) to trace faults in production runs, or (b) devise circuits or articles for future production. Invariably the larger firms are capable of pursuing both lines of development.

Fault tracing involves an intimate knowledge of the characteristics of each item or circuit in a radio set of any type. In general, the fault can be fairly easily located, its correction is a matter of greater complexity. A standard series of tests can be employed along the lines proposed from time to time in various articles in the technical Press. Continuity and such like tests are effective merely in tracing mechanical defects, such as the fracture of coil windings, other tests may indicate design defects. With mechanical defects, if these occur over-frequently then there is something wrong with the manufacturing process, in either (a) the machine setting, (b) material, or (c) design. Each of these requires further investigation, analysis and rectification of the defective stage or stages. Production research of this kind is more or less a matter of routine, but the introduction of design improvements involves a much higher standard of technical ability.

The design and other improvements incorporated in the development of new models also require skilled attention. Not only must these new designs be free from defects referred to in the previous paragraph, but they must also include distinct improvements in performance over those of the old models. Experience shows that, in general, the introduction of any new unit or circuit interferes in some way with the existing set, with the result that to increase the performance an extensive "re-shuffle," with possibly the introduction of other adverse features, may take place. It is the lot of the development engineer to find a solution of these conflicting factors, invariably by seeking a compromise between them.

Some Problems in Radio Development

Commencing from the source of radio transmissions, namely the microphone, this must be so designed that it is responsive to a wide range of sounds, both in volume and in pitch. When resistance variations are used to extenuate the signals then the diaphragm must be capable of pure vibrations or flexures without introducing any inherent tones. The characteristics of diaphragms have been the subject of a number of experiments, particularly in relation to telephone microphones. In a similar manner, the characteristics of piezo-electric crystals in their relationship to microphone performances is of paramount importance, factors which are of interest to designers include the piezo-electric coefficient, *i.e.*, variations in resistance per unit pressure variation, variation in unstressed resistance, crystal structure, effects of purity, etc. It should be observed that from the full appreciation of all this information the difficulties underlying the design of a very small microphone can be overcome to some extent.[1] Further developments in this direction have been dealt with by Olson[2] and Drueson.[3]

To discuss briefly and without entering too fully into the technical details of transmitters and receivers is an almost impossible task. There are many fields for development in the design of both sets, not simply in the arrangement of the individual units,[4] but also in their design and manufacture. Thus the design of the elements of vacuum tubes[5] depend upon the grid size, bias and electrode capacities; the development of special valves for V.H.F. work also introduces the study[6] of emission rates in relation to the element dimensions. (Before proceeding further it might be recalled that in the development of the earliest valves, Fleming merely took advantage of a known phenomena from "pure science," namely, the radiation—and subsequent re-entry—of charges from a conductor). It might also be pointed out that research on radio equipment is not confined entirely to the creation and control of microscopic electrical currents, but may also include such practical matters as the sealing of the wires in valves. Although the foregoing articles have dealt only with valves, the radio engineer is also concerned with the performance of condensers (a typical investigation is given by Brotherton[7]) of rectifiers,[8] transformers, condensers, and even switches, plugs, etc. In most of these investigations the experimenters have followed up the applications of recognised scientific facts to radio problems.

Similarly, aerials have received the attentions of radio scientists, particularly in relation to shape, design and sensitivity. The importance of the design of this item, and the significance of the related phenomena[9] has come into prominence during the past few years in relation to the design of direction-finding apparatus. It is interesting to note that the importance of the earth return has not been neglected—in fact, direction-finding via earth return may be a further line for research and development. Some work on earth effects has been recently published by Grosskopf and Vogt.[10]

Without dwelling further on the details of radio circuits, attention is

drawn to the various researches made for radio engineers in the suppression of interference, effects of atmospheric conditions, etc. Some references to the effects of mountains on the reflection of emissions include the paper by Busignes.[11] There have been a vast number of contributions to the technical Press dealing with the effects of interference and the atmosphere on radio transmission and reception.

Research Organisations

Radio research is carried out to some extent by all progressive firms and also by official institutions.

The Radio Research Board of the Department of Scientific and Industrial Research may be regarded as the chief independent organisation with extensive laboratories for original research work. Other laboratories are maintained by the British Broadcasting Corporation and various Government departments or services, such as the Post Office, Army, Navy, and Air Force. In addition, the work carried out by the Institution of Radio Engineers, the Electrical Research Association and other professional or trade organisations is of beneficial influence to the whole industry.

The scope of the work covered by each organisation is very extensive. Some idea of the activities of individual concerns are given in the technical Press, as in the description of the work of the Electrical Research Association given in *Engineering*, Vol. 157, No. 4,075, 18/2/44, p. 137.

Private Research

There is undoubtedly a vast scope for research among engineers and technicians. Not only can a person gain higher degrees by the publication of thesis based on research, but if not university graduates they can gain considerable prominence by the publication of papers to the technical institutions, or of treatise or textbooks. (It should be noted that notoriety of the kind referred to is not meant to encourage vanity, but as a means whereby the engineer can come to be regarded as a specialist in certain subjects and will be approached with regards to these matters; this accessibility will be invaluable to his firm and accordingly to the engineer himself). Furthermore, the experience which is gained from undertaking research is of considerable value, for, besides broadening a person's outlook towards the design, production and maintenance of engineering equipment, research experience enables him to appreciate the significance of other research reports and to apply all the latest information to the benefit of his own equipment.

It is the author's experience, confirmed from observations on the careers of many leading engineers, technicians and scientists, that *research experience can be acquired during a person's spare-time.* This statement has been treated to greater length and in more detail in the author's recent booklet[12] which describes the reasons for undertaking research and its applications to industry.

In radio engineering there is a very wide field which many enthusiasts—both professional and amateur—should follow. Thus instead of simply "tinkering about" with new sets, the enthusiast should adopt some particular subject which might be studied in great detail. As explained by the Advisory Bureau for Research, 70 Victoria Street, S.W.1, in a recent memorandum, some useful work may be done simply from a literary survey of one particular subject—a useful occupation when components are so scarce, and a lucrative one from the publication of books or articles. Incidentally, this Bureau (from which further details may be obtained) also prescribes subjects for specialist study in this way.

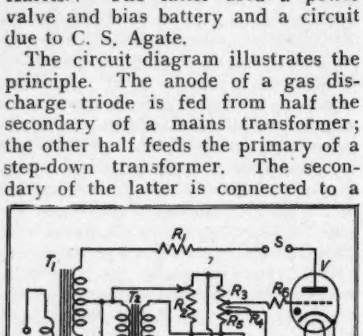
Many readers will already have a "pet" subject in which they are interested and it is suggested that they should employ their leisure to the useful study—both by reading books and actual experiments—on specialised subjects. It should be remembered that radio-location was developed by Sir Robert Watson-Watt as the result of this interest in the reflection of radio active propagations while serving in a junior capacity under the Department of Scientific and Industrial Research. An account of the origin of much of this work reveals that for some time it was the part-time hobby of several enthusiasts, many of whom have risen to high positions in this new branch of radio engineering.

Electronic Drop Recorder

By W. SCHLAPP*

IN experimental work in physiology it may be convenient to record secretion rates by means of a drop recorder. Many kinds of instrument have been used for this purpose. That described here is an A.C.-mains version and resembles one described by D. T. Harris.† The latter used a power valve and bias battery and a circuit due to C. S. Agate.

The circuit diagram illustrates the principle. The anode of a gas discharge triode is fed from half the secondary of a mains transformer; the other half feeds the primary of a step-down transformer. The secondary of the latter is connected to a



T_1 Radio transformer 250-0-250 V, 4 V, 2 A
T_2 Step-down transformer 3 : 1
R_1 2,000 ohms — R_5 0.1 meg.
R_2 0.1 meg. — R_4 0.05 meg.
R_3 0.05 meg. — R_6 0.05 meg.
S Signal terminals — D Drop contacts
V Cossor GDT4B

resistance network whose relation to earth is controlled by a potentiometer. This makes it possible so to set the magnitude and phase of the potential applied to the grid that the valve passes no current. A portion of the network may be short-circuited by a drop of secretion falling between the contacts provided. Polarisation of the contacts does not take place as the current applied is alternating. The consequent change in bias allows the valve to conduct and the available current can be made to operate a suitable signal or counter.

* Physiology Dept., Manchester University.
† D. T. Harris (1931) *J. Physiol.*, *71*, Proc. xxii.

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Ion Burn in Cathode-Ray Tubes

By G. LIEBMANN, D.Phil., F.Inst.P.

ION burn is a well-known fault of cathode-ray tubes employing magnetic deflection of the electron beam; it afflicts most modern television cathode-ray tubes to a greater or lesser degree. In electrostatically focused tubes it appears as a small dark stain right in the centre of the fluorescent screen which increases in density and, to some extent, in size with prolonged use of the tube. In magnetically focused tubes, the darkening or discolouration is much less intense but covers a fairly large circular area, approximately 1½ in. to 2½ in. in diameter.

This defect was first described in 1935 by Ardenne,[1] who recognised that it was due to negative ions which destroy the fluorescence of the screen surface. The first more detailed investigation of the phenomenon is due to Bachman and Carnahan,[2] and further studies were carried out by Broadway and Pearce[3] and by Schaefer and Walcher.[4] All these authors analysed the ion stream by applying a strong transverse magnetic field to the cathode-ray beam, thus using the cathode-ray tube as a "mass-spectrograph." The deflection of charged particles in a transverse magnetic field is proportional to $\sqrt{e/m}$, e being the charge and m the mass of the particles. Thus particles with different mass can be separated easily as the charge is usually equal to the charge of one electron, rarely of two electrons. If the accelerating voltage, the field strength and length of the deflecting magnetic field and its distance from the fluorescent screen are measured, the value of the mass m and hence the nature of the ion can be determined.

A considerable variety of ions have been detected in this way within the cathode-ray tube beam, and the total number of different ions so far observed is at least thirty-four, although some of these occur only in minute traces and have not been definitely identified. The strongest components appear to be hydrogen, oxygen, the halogens and various hydro-carbons.

The total ion current is usually of the order of 10^{-10} to 10^{-9} amps, or 10^{-5} to 10^{-6} times smaller than the electron current emitted under the same operating conditions. It is therefore rather surprising that it causes so much damage, and the destructive process must be highly efficient. Ion bombardment of the fluorescent screen for several hours with the above mentioned values of ion current corresponds only to one single ion per 10^{-2} to 10^{-3} unit cells of the crystal lattice of the screen surface. Thus it would seem likely that almost every ion destroys permanently one of the excitation centres distributed through the crystal lattice of the fluorescent material; but it is not yet known how the ions "seek out" the excitation centres, or how the actual destruction process operates.

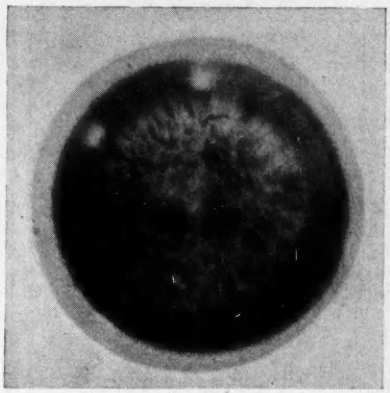

Fig. 1. Ion Burn

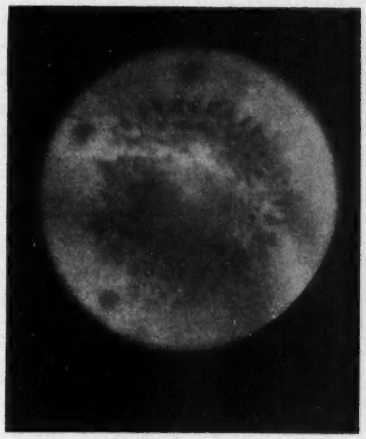

Fig. 2. Electron emission image of cathode

An important qestion is that of the origin of the ions. It was believed some years ago that the ions were mainly generated near the cathode by ionisation of residual traces of gas, left in the tube during the exhaust process or leaking gradually out of the electrodes or the wall coating. This view appears correct in very few cases only; the exhaust technique has been greatly improved in the last few years, but ion burns are found as frequently as before, and there is no correlation between ion formation and residual gas pressure within the tube. It was noted by Broadway and Pearce that the ion current seems to be roughly proportional to the electron emission of the cathode. Although this fact can be interpreted in several ways, it was reasoned by Schaefer and Walcher that the likely source of the most obnoxious ions is the oxide coating of the thermionic cathode. The activation process of the oxide cathode which is employed in almost every modern cathode-ray tube is going on continuously during the operation of the tube, replacing barium evaporating from the cathode surface and generating oxygen which may leave the cathode in ionised form, besides many other ions due to the break-up of residual traces of the binder material of the cathode coating or to contaminants.

It was found by the writer[5] that the ion burn shows in many cases a "structure" which resembles closely the electron emission pattern of the cathode itself. This appears to be a direct experimental proof that mostly (although not necessarily in all cases) the negative ions are indeed issuing from the thermionic cathode. Moreover, the *local* electron current density and rate of negative ion production appear to be rather closely correlated. This would support the theory that the ions responsible for the destruction of the surface of the fluorescent screen are mainly generated by the activation process of the cathode.

A good example of such "ion burn structure" is shown in Fig. 1. This ion burn was produced by running for 3 hours the heater of a new all-magnetic television type cathode-ray tube with 9.0 volts instead of the normal operating value of 6.3 volts, drawing a beam current of 600 μA at an

accelerating voltage of 6 kV. During this experiment, a small scan was applied to the deflection coils so that the pattern of the corresponding electron emission image of the cathode was suppressed. After this time, the ion burn had become just discernible at the normal accelerating voltage of 6 kV when the screen was scanned with a slightly diffuse electron beam, but stood out in good contrast after the voltage had been lowered to 1 kV, as the excitation of the fluorescence was then confined to the partly destroyed surface layer of the screen. The photograph of Fig. 1 was taken under this condition. The corresponding electron emission image of the cathode, obtained under the same conditions as the ion burn, except that the scan was switched off, is shown in Fig. 2. It can be seen that the ion burn reproduces, in negative, the electron emission structure of the thermionic cathode quite faithfully, except for a few details. (For instance, the ion burn shows a small rather intense spot near its centre which has no counterpart in the electron emission image. This centre spot may be due either to doubly charged ions or, though less likely, to ions not originating at the cathode).

The fact that the ion burn formation is directly due to the operation of the oxide cathode is responsible for the poor results of earlier attempts to eliminate this defect. Prolonged ageing of the cathode without the application of high voltages to the tube region containing the fluorescent screen, and later operation of the screen at fairly high anode voltages has, so far, been the only effective means of minimising this fault. Farnsworth's suggestion of making the electron gun point to the tube wall near the screen instead of towards the screen itself, and deflecting the electron beam back towards the screen centre by an auxiliary magnetic field which does not affect the ions overcomes indeed the ion burn trouble, but leads to complications and to deterioration of the obtainable definition, paticularly at high beam currents. However, new hope of eliminating ion burn in a more satisfactory way is offered as a by-product of an improved screen metallisation technique proposed recently.[6]

References

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[3] L. F. Broadway and A. F. Pearce, *Proc. Phys. Soc.* (London), **51**, 335 (1939).
[4] H. Schaefer and W. Walcher, *Zeit. f. Phys.*, **121**, 679 (1943).
[5] G. Liebmann, *Nature*, **157**, 228 (1946).
[6] C. H. Bachman, *G. E. Rev.*, **48**, 13 (1945).

Two Useful Laboratory Instruments

ALL-POWER Transformers, Ltd., have issued particulars of two laboratory instruments which will prove of value to design and research laboratories.

The first is a regulated power supply giving an output voltage which can be varied between 250 and 400 volts with a maximum current output of 250 milliamperes. The output voltage can be adjusted smoothly and accurately to any value within the stated range and is substantially independent of mains voltage variations between + 10 per cent. and − 15 per cent., and of load variations between zero and full load. The residual output ripple is of a very low order. The unit is housed in a steel case finished grey cellulose enamel; the overall dimensions are 18 in. by 13½ in. by 14 in., and the weight 71 lb. nett.

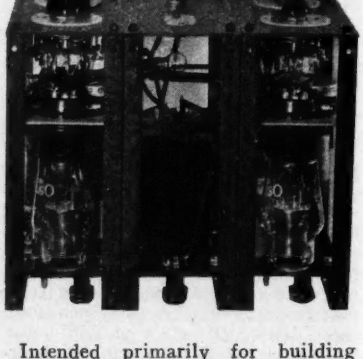
The other instrument is a high voltage test set (*see* photograph) intended for general purpose use in development laboratories, and is a convenient means for checking the insulation of all types of components; the provision of a D.C. output is particularly useful for the testing of condensers. Tests may be made at voltages between 1,000 and 5,000 with either A.C. or D.C. and give a clear indication of breakdown or leakage. Essentially the instrument is a "Flash Test" but with refinements which considerably widen the scope of its usefulness. Also housed in a steel case, the overall dimensions of this instrument are 12 in. by 10 in. by 11¾ in., and the weight 24 lb. nett.

—All Power Transformers, Ltd., Gladstone Road, S.W.19.

An Electronic Time Switch

THE "Op-Timer," an instrument for electronic automatic time control, has been developed by Messrs. Process Control Gear, Ltd., 56 Victoria Street, St. Albans, Herts.

The general principle of operation of the unit is simple. A capacitor is charged and the negative plate connected to the control grid of a thyratron, and this negative grid voltage prevents the flow of anode current through the valve. The charge is then allowed to leak away through a variable resistance, and after a period fixed by the time constant of the resistance and capacitance, the voltage falls to the critical value at which the thyratron "strikes," whereupon the anode current flowing through the coil of a relay causes it to pull in. Argon-filled thyratrons have been chosen in preference to the mercury-vapour type so as to obtain an operating characteristic which is insensitive to change of ambient temperature.



Intended primarily for building into motor control panels, the standard housing of the Op-Timer is an open-type framework with sheet-steel front panel, but protecting covers of light steel can be fitted if the equipment is required for independent mounting.

A standard model is available which will continuously open and close two separate circuits in turn and in which the duration of each of the two operations is separately controllable by 70 effective steps of approximately one second each.

The dimensions of the Op-Timer are 9 in. by 6½ in. by 8½ in. deep (approx.). The open type, as illustrated, is £16 10s. 0d.

NOTES FROM THE INDUSTRY

A British Research Company

The formation of a British Research Company by the industrial group, of which British Insulated Callender's Cables, Ltd., and Automatic Telephone & Electric Co., Ltd., are principals, has been announced. An authorised capital of £100,000 has been jointly contributed by the two parent companies and the new company is in process of setting up laboratories at Taplow Court, near Maidenhead, Berks. The board of directors includes Mr. P. V. Hunter, C.B.E., M.I.E.E. (director and engineer-in-chief of B.I. Callender's Cables) as chairman; Air Vice-Marshall O. G. Lywood, C.B., C.B.E., as managing director, and Dr. T. Walmsley, C.B.E., Ph.D. (formerly with the Post Office) as director and chief engineer.

It is interesting to note that the laboratory personnel is being recruited from among scientists and technicians employed during the war by the Air Ministry and other Government Departments.

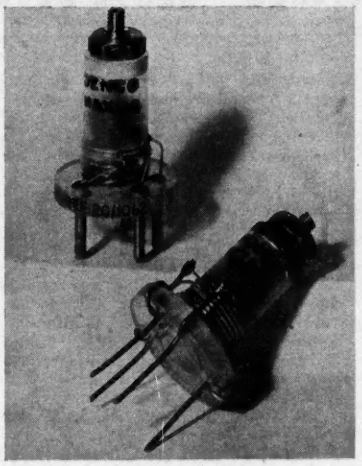
A New Welding Machine

A universal machine, the Pyroweld, for soldering, brazing, arc and resistance welding has been developed by The Acru Electric Tool Manufacturing Co., Ltd., of Ardwick, Manchester, 12. The Pyroweld solders any metal below 30 gauge, even heavy castings, brazes any metal up to 3/16 in. thickness, and welds from 18 s.w.g. to ½ in. The maximum soldering capacity is 150 amps. at 70 V. The Pyroweld consists of an air-cooled transformer in connexion with a specially designed choke. There are two control wheels, one for varying the current and the other the voltage; an ammeter is provided which enables the controls to be set for the required optimum amperage.

Ardux Cement

Aero Research, Ltd., makers of Ardux Cement, recommend the use of the new Ardux 120 instead of Ardux powder. It is not suitable for metal-metal bonding but will give excellent results when one of the materials in the bond is of a porous nature, such as wood, fabric, or wall board.

Ardux cement was largely used in the manufacture of the plastic cases for mine locators recently described in this journal by Mr. S. S. West.



Miniature Coils and Formers

By the use of polystyrene formers, iron dust cores and Litz windings, the Denco "Maxi-Q" range of coils has many outstanding features. The coils have adjustable cores, thereby simplifying receiver alignment, and complete coverage of long, medium and normal wavebands (10-1,800 metres or 170 Kc. to 32 Mc.) can be obtained with the use of a 300 pF tuning condenser. The coils are supplied in two types: plug-in type which fits a standard octal valve holder, and chassis mounting type.

The dimensions of the coils are as follows: former diameter, 0.5 in. (12.7 mm.); overall height, excluding pins, 1.375 in. (35 mm.); base diameter of plug-in type, 1.0 in. (25.4 mm.).

The sole distributors in Great Britain of the "Maxi-Q" coils are Messrs. Tele-Radio (1943), Limited, 177a Edgware Road, London, W.2, from whom further information can be obtained.

Philco Patents

The Philco Corporation in U.S.A. has licensed the Radio Corporation of America to use 600 Philco patents and inventions relating to television and radio receivers and gramophones. The corresponding Philco rights in Great Britain are licensed to Airmec, Ltd., manufacturers of Philco radio and television receivers, and a subsidiary of Radio and Television Trust.

E.M.I. Institutes, Ltd.

Electrical & Musical Industries, Ltd., have formed a new organisation to be known as E.M.I. Institutes, Ltd. This ambitious scheme is planned to provide technical training of all kinds in the fields of television, radio, radar and the associated techniques for all types of students. The London Radio College has been acquired as headquarters for the new organisation, and Professor H. F. Trewman, M.A. (Cantab), M.I.E.E., M.I.Mech.E., has been appointed managing director and principal. Professor Trewman's qualifications are widely known and for many years he has been connected with the various branches of technical training; in addition he has had wide contact with production engineering.

R. R. Development Laboratories Ltd.

This company has been formed with the object of developing new devices for the electronic industry. Castings, turnings, prototype construction, chassis and cases are, however, also undertaken. For cases and chassis, R.R. Development Laboratories specialise in the use of aluminium manganese 1¼ per cent. alloy. High quality amplifiers, with low intermodulation distortion, and a medium priced signal generator, are in the course of production.

The directors of this company, whose offices are at 83 Barnard Road, Bradford, Yorks, are Mr. G. C. L. Campbell, B.Sc., and Mr. A. E. Newman, both of whom were previously with the General Electric Co. in the Radio Communication Development Laboratories.

Change of Address

R. S. Amplifiers, Ltd., have moved to a new and larger factory at Reynolds Road, Acton Lane, London, W.4. Telephone: CHIswick 1011/3.

The London office of the British N.S.F. Co., Ltd., makers of Oak switches, is now at 9 Stratford Place, London, W.1. Telephone: MAYfair 5234.

Television Servicing

Mr. D. S. B. Shannon, who was chief television engineer to Halcyon Radio, Ltd., from 1935 until 1938, has now taken up television servicing. His address is 6 Coram Street, Russell Square, W.C.1. Telephone: TERminus 5666.

BOOK REVIEWS

Varnished Cloths for Electrical Insulation

H. W. Chatfield and J. H. Wreddon (London : J. & A. Churchill, Ltd., 1946, 21s.) x + 255 pp.

Dr. H. W. Chatfield and J. H. Wreddon, who are chemists engaged in the varnish and electrical industries respectively, have performed a valuable service to these and the textile industry by their clear and orderly exposition of the technical features of varnished fabrics in this book—the first to deal exclusively with these important insulating products.

Commencing with introductory notes on the present requirements of varnished cloths, such as flexibility, thickness, strength, and resistance to oils and other influences, followed by a rather brief review of the types of varnished cloths and a few of their typical uses, the textile supports for the varnishes are then dealt with at some length. A chapter is devoted to the varnishes used for impregnation and surface coating of the fabrics, with a useful exposition of the mechanism of the drying processes of varnishes: evaporation, oxidation and polymerisation. Having thus dealt with the raw materials, the process of varnishing and the equipment employed for this are considered, followed by notes on the storage of textiles, varnishes and varnished cloths.

To most engineers it is the properties of the *finished* products which are of greatest importance, and they will not be disappointed as these features are very fully dealt with in the longest chapter (Chapter VII). The properties are, of course, closely associated with the methods used for analysis and testing of varnished cloths, which form the subject of Chapter XI, and, taken together with the reproductions of the British and American standard specifications (*e.g.*, B.S. 419) and methods of testing given in the Appendix, furnish a valuable and complete picture of technical aspects of main interest to the user.

A most interesting and useful monograph on " the impregnation of textile supports with special reference to occlusion of air " is given in Chapter VIII, but it is difficult to see why this diversion—important though it is—should be sandwiched between the chapters dealing with properties and testing. There is some confusion over the terms " electric strength " and " dielectric strength," both being used rather indiscriminately. In this country, electric strength is the accepted term, as given in the B.S.I. Glossary and used in B.S. 419. It is a pity that bias cut tapes are almost entirely neglected, and the seamless variety are not mentioned. Considering the special manufacturing technique involved, and the importance of their uses in the electrical industry, the lack of detailed descriptions of the nature, methods of manufacture, properties and uses of these tapes, is a serious omission.

An outstanding feature of this book is the number of excellent photo-micrographs which enable the reader to get an authentic and convincing picture of the physical details of the fabrics and varnish films. There is no doubt that this book fills a long-felt need for manufacturers and users of varnished cloths, and conveys knowledge and practical information almost unobtainable elsewhere. It should, therefore, be of considerable value to numbers of engineers, chemists, textile technologists and many others.

R. I. MARTIN

An Experimental Course in the Fundamental Principles of Radio

R. H. Humphrey, M.Sc., F.Inst.P., 194 pp. 122 Figs. (Pitman & Sons, 12s. 6d. net).

This book covers the experimental work needed for the basic wireless course for Service radio mechanics. The date of the preface is August, 1944. At that time, and, in fact, for a long time before, there was need of such a book as this, but now that almost all the Service training in the technical colleges has finished, one is bound to say that, good though the book is, its usefulness is limited to very elementary students. The reviewer thinks that this book would make a very useful adjunct to Nelkon's " Physics and Radio " for, say, C. and G. Grade I students.

The first three chapters describe simple D.C. experiments, electromagnetism and measuring instruments. Some four pages are spent on an interesting description of multi-range instruments. Chapter IV is a short one on condensers, describing the usual methods for the measurement of capacitance, insulation resistance and the "discharge" curve. "Alternating Current Measurements" are dealt with in Chapter V. The experiments in this chapter form a very useful introduction to the notions of the behaviour of reactive components in A.C. circuits. In a section on the use of the C.R.O. it is not made clear that the Y_1 and Y_2 plates of the double beam tube produce deflections which are spatially 180° out of phase when the deflecting voltages are electrically in phase. This has been found to be a difficulty with elementary students.

" The characteristics of valves and metal rectifiers " is the title of Chapter VI. The valves are well looked after, up to a point. Metal rectifiers have one experiment. The reviewer would like to have seen the bridge and the voltage doubling circuits used. Both are simple enough with metal rectifiers and within the competence of elementary students. The " ordinary " valve characteristics are done well, but, in these days of multi-electrode valves, an experiment on the " gating effect " of the suppressor in a pentode, and another on the change of g_m of a hexode with potentials applied to the modulator grid, would be useful. This latter experiment, in fact, is almost essential for the understanding of hexode frequency changing.

Further experiments involving the use of the C.R.O. are described later in the book, and, in them, the C.R.O. is connected between the anode of the valve and H.T. +. In the first place, the anode load of a valve is essentially connected between anode and cathode, and, in fact, a large condenser is always used to make the H.T. + line " earthy," hence the C.R.O. should be connected to anode and the earth line; moreover, there is a serious danger of shortcircuiting the H.T. supply if the E. terminal of a metal-cased C.R.O. is connected to H.T. +.

The remaining chapters deal mostly with experiments at high frequency: oscillators, detectors, modulation, neutralising, etc. There is a number of small points of which there might be criticism, but these points *are* small.

Mr. Humphrey is the Acting Head of the Physics Department of the Sir John Cass Technical Institute. The "physics" of this book is in keeping with its parentage. The "engineering" has not quite the same breeding.

D. O'BRIEN

Handbook of Technical Instruction for Wireless Telegraphists

H. M. Dowsett and L. E. Q. Walker. 660 pp. 618 figs. (Iliffe & Sons, Ltd., 30s. net.) 8th. Edition.

If there is any wireless enthusiast who has collected all seven editions of this well-known text-book, he will have a reasonable record of the progress of marine communications. The first edition, published in 1931, dealt with ship-to-shore spark transmitters and the magnetic detector. The present edition deals not only with valve transmitters for all

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BOOK REVIEWS (*Continued*)

classes of ships, but also with marine D.F. sets and echo-sounding apparatus.

The preliminary theory, which occupies approximately half the book, has been brought up to date and more matter has been added on synchronous, induction, and repulsion motors and on vibrator power packs.

The book is beautifully printed and produced, the diagrams being particularly noteworthy for their clarity. Complete circuit diagrams of the Marconi sets are included, and there is a good index.

It is an essential requirement for passing the P.M.G. certificate and can be confidently recommended to all prospective wireless telegraphists.

G.P.

Basic Mathematics for Radio Students

F. M. Colebrook, B.Sc., D.I.C., A.C.G.I. 77 diagrams. 270 pages. 10s. 6d. Iliffe & Sons.

Few speakers at war-time discussions on training before the Radio Section of the I.E.E. failed to stress the importance of mathematics as a tool for the radio engineer. Though there have been some American books presenting mathematics in a manner especially suited to the needs of the radio technician, "Basic Mathematics for Radio Students" is, as far as the reviewer is aware, the first English publication to appear in this field, and the subject is presented with the lucidity we expect from this well-known contributor to radio technical journals. Criticism can be levelled at the scarcity of electrical and radio illustrative examples (the first does not occur until page 88), the manner of placing paragraph headings (see paragraph 50 on page 89), and the general mix-up of text and examples. The latter defect is particularly evident on page 53. Prof. Whitehead is often quoted, but the title of his book is not given.

The book has seven chapters; the first, concerning fundamental ideas of elementary algebra, forms a useful introduction for the more practically-minded engineer, and may be skipped by the mathematically-biased student. Chapter 2 deals with indices and logarithms in a very clear manner. The third chapter considers the solution of equations and also complex numbers. It contains most useful examples of reducing higher order equations to quadratics, and there is a helpful discussion on the graphical meaning of real, imaginary and equal roots. Continuity, limits and series are the subjects of chapter 4, which is perhaps the high light of the book. The elementary treatment of geometry and trigonometry given in chapter 5 slides almost imperceptibly into a discussion of vectors, the operator "j" and hyperbolic functions. A welcome addition here would be a diagram showing how hyperbolic angles and functions are derived from the hyperbola. Chapter 6 on differential and integral calculus is linked with "limits" of chapter 4, and, though perforce sketchy, is adequate to the normal needs of the radio engineer. The last four pages are devoted to Fourier analysis.

The final chapter shows the tool in operation in dealing with electrical oscillations, progressive and stationary waves, and the fundamental laws of networks under forced and free oscillatory conditions. The back E.M.F. and back voltage illustration needs amplifying to avoid confusion to the student. There are not many misprints, a root sign is missing on page 47, the index "2" has been lost from the last-but-one equation on page 180, an index $\frac{1}{2}$ is inverted on the next page, and $\frac{1}{2}\pi$ should be $\frac{1}{2\pi}$ on page 231.

The book can confidently be recommended to the technical college student and undergraduate, but the self-taught technician will find the material less easy to assimilate.

K. R. STURLEY

Principles of Electricity Illustrated

By R. C. Norris 380 pp. + figs. (Odhams Press 8s. 6d. net).

The aim of this book is to present a complete outline of electrical theory and practice for students and practical men who need to enlarge their knowledge of the subject. The fifteen chapters are written by various experts, and include such items as A.C. Effects, A.C. Motors, Transformers, Rotary Converters, Measurement, Distribution, and Electronics.

In this the book tends to belie its title, as much of the matter in the text progresses beyond the principles of the subject and becomes abstruse in parts. The student will have to read carefully to avoid mental indigestion, but the numerous drawings and explanatory captions are a help.

The inclusion of a chapter on electronics is in keeping with the modern trend in electrical text-books, but it is hoped that in the next edition the author will be allowed more than 20 pages to expand his subject. After all, the cathode-ray tube is now found in most laboratories and deserves more than a bare outline of its operation. But still, the editor might argue that the book dealt only with principles! At the published price, it is excellent value for the money.

G.P.

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ABSTRACTS OF ELECTRONIC LITERATURE

C. R. TUBES

High-speed Photography of the Cathode-ray Tube
(H. Goldstein and P. D. Bales)

Techniques are described which were developed for periodic recording of single, fast traces on a cathode-ray tube at rates up to 4,000 per sec. Factors affecting maximum writing speed are discussed, and it is shown that speeds as high as 70 cm/microsec can be obtained without sacrifice of deflection sensitivity, and using commercially available tubes and films. Several 16 mm. cameras, adaptions of existing models, are described in which the film moves continuously and at high speeds.

—*Rev. Sci. Inst.* 17, March, 1946, p. 89.*

A Three-Beam Oscillograph for Recording up to 10,000 Megacycles
(G. M. Lee)

A description is given of a three-beam high-speed micro-oscillograph which extends the range of application of single-sweep of oscillographic recording by a factor of approximately ten in frequency over previous limits imposed by transit-time distortion. The reduction in deflection sensitivity attributable to transit-time effect is calculated to be 4 per cent. at 3,000 Mc. and 40 per cent. at 10,000 Mc. Single-sweep oscillograms of 3,000 and 10,000 Mc. oscillations and breakdown transients with fronts of the order of 10^{-9} second duration.

—*Proc. I.R.E.*, March, 1946, p. 121W.

High-speed Oscillograph
(N. Rohats)

Oscillograph for transient measurements has rapid writing speeds, in excess of 50 centimetres per microsecond. Simultaneous viewing of cathode-ray tube screen by recording camera and operator facilitates positioning and focusing the trace between measurements.

—*Electronics*, April, 1946, p. 135.

A Rapid Cathode-Ray Method for the Determination of Low Magnetic Susceptibility
(J. Convey)

This article describes a simple A.C. inductance bridge method that has been developed and used in the Admiralty Laboratory, Sheffield, for the past three years to determine the magnetic nature of materials of very low magnetic susceptibility. The bridge consists of two accurately matched coils balanced by two resistance arms. Materials under test are inserted in one of the coils and the out-of-balance voltages after suitable amplification are indicated on a cathode-ray tube screen. Calibration of the instrument is made by the use of pure substances of low magnetic susceptibility. A typical susceptibility calibration curve is given and a list of standard substances.

—*Jour Sci. Inst.*, April, 1946, p. 71.

CIRCUITS

Reflex-Klystron Oscillators
(E. L. Ginzton and A. E. Harrison)

A comprehensive analysis of reflex klystrons is developed by considering the electrons as particles acted upon by forces which modify their motion. The analysis is similar to earlier explanations of electron bunching in a field-free drift space and predicts a similar current distribution when bunching takes place in a reflecting field. The effect of the bunched electron beam is treated qualitatively by considering the effect of the beam admittance upon a simple equivalent circuit. A quantitive mathematical analysis based upon oscillator theory is also derived, and the results are presented in a series of universal curves which are used to explain the operating characteristics of these tubes. Power output, efficiency, starting current, electronic tuning and modulation properties are discussed. Some general remarks on reflex-oscillator design considerations are also included.

—*Proc. I.R.E.*, March, 1946, p. 97P.

Synchronising Generators for Electronic Television
(A. R. Applegarth)

The system of electronic circuits employed to generate the complex waveforms required as a base for television picture transmission is described. It comprises four principal sections which are: (1) source of accurately-timed pulses; (2) frequency-divider chain; (3) components-generating circuits; and (4) signal-synthesis circuits. The various means for accomplishing these functions is briefly discussed, and illustrated by circuits which have been used successfully for such purposes in practical applications.

—*Proc. I.R.E.*, March, 1946, p. 128W.

Engineering Approach to Wave Guides
(T. Moreno)

Practical considerations in the choice and fabrication of wave guides are considered from the engineering viewpoint. The advantages of hollow, rectangular guides are described by comparison with coaxial cable characteristics at super high frequencies.

—*Electronics*, May, 1946, p. 99.

Grounded-Grid Power Amplifiers
(E. E. Spitzer)

Radio-frequency power amplifiers using grounded-grid circuits operate at higher frequencies and can handle wider bandwidths than capacitance-neutralised, grounded-cathode circuits. These advantages suit the grounded-grid circuit to television, f.m., and industrial uses. The article calls attention to this circuit, points out its advantages and characteristics, and shows how such a circuit is designed.

—*Electronics*, April, 1946, p. 138.

ELECTRON OPTICS

Preparation of Electron Microscope Specimens
(A. M. Cravath, A. E. Smith, J. R. Vinograd and J. N. Wilson)

A method of preparation of electron microscope specimens for determination of particle size distribution in aqueous solutions is described in which small droplets of the suspension to be examined are deposited from a mist upon a specimen film. The surface of the film is treated to promote wetting by the droplets. The entire residue left by a whole droplet is made available for examination by this procedure, which also promotes uniform dispersion of the deposit. Results obtained with polystyrene latex are illustrated and an alternative procedure for surface hydrolysis is described.

—*Jour. App. Phys.*, April, 1946, p. 309.*

Further Improvement in the Resolving Power of the Electron Microscope
(J. Hillier)

Although the calculated maximum resolving power of the magnetic electron microscope has been found to lie in the range 5 A to 10 A, existing instruments have very rarely given values of less than 20 A. A gun has been developed which is claimed regularly to provide images showing resolutions of the order of 20 A. The reason advanced for the delay in this development is that no account has been taken of the lack of axial symmetry in the magnetic field of the lenses. It is reported that a few images better than 13 A, and possibly as low as 8.5 A, have been obtained, using a lens having a greater degree of axial symmetry.

—*Jour. App. Phys.*, April, 1946, p. 307.*

Filmless Sample Mounting for the Electron Microscope
(J. H. L. Watson)

A method is described for supporting airborne particles upon thin glass fibres where they are built up in chains and may be examined by electron microscope. Contrast and resolution are increased, the specimens being particularly useful for stereoscopic studies. Special reference is made to the study of carbon particles mounted in this fashion, these being formed by pyrolysis of acetylene, and occur naturally in pronounced chains. Evidence for the crystalline nature of this carbon is rendered visible in micrographs.

—*Jour. App. Phys.*, February, 1946, p. 121.*

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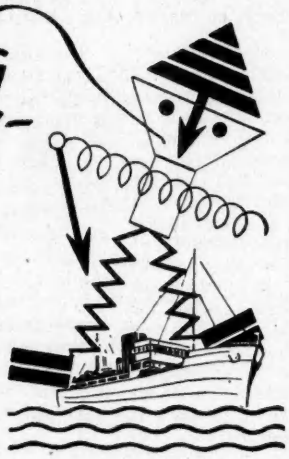

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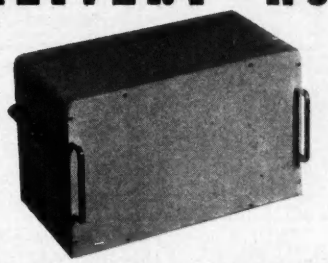

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Electronic Airspeed Indicator (Altitude and Temperature Compensated)

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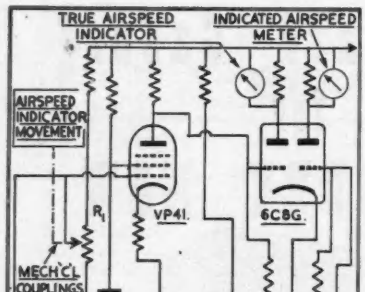

IN an effort to relieve aviators of somewhat unnecessary calculations an instrument has been proposed (Prov. Spec. 8720/46) which indicates the "True Airspeed" of a plane, as distinct from the indicated airspeed of conventional mechanical instruments.

It is well known that air density varies with altitude and therefore any indicator which relies on air pressure will give readings which vary according to the planes altitude. The proposed instrument is actually a mechanical airspeed indicator electronically coupled to an altimeter to give automatic compensation for altitude.

The principle of the indicator is shown in the circuit diagram and it will be seen that a standard airspeed indicator movement is arranged to vary a potentiometer R_1 in the grid circuit of the amplifying valve V_1, the voltage across the potentiometer thus becomes a function of the velocity of the plane. To compensate for variations of altitude a standard aneroid altimeter movement is coupled to a potentiometer R_2 connected in the cathode circuit of V_1, variations of altitude will therefore cause variations of grid bias. The valve V_1 is a variable gain pentode operated on a grid base where the amplification factor alters in a linear manner with respect to grid bias, and therefore the stage gain becomes a direct function of the altitude.

The altimeter must be compensated for temperature variations and a bridge circuit comprising R_3 and R_4 is arranged so that the moving contacts are connected across R_2. The resistance R_3 has a voltage gradient which is a direct function of actual air temperature, while R_4 has a voltage gradient corresponding to the "International Air" temperature at the height indicated by the altimeter. Any variation of temperature from "international" standards causes a corresponding voltage to develop between the moving contacts of R_3 and R_4, this voltage being a measure of the temperature correction required.

An instrument of the type outlined could play a large part in the small privately-owned aircraft visualised for the post-war era. The owners of this type of plane will not necessarily be technically minded and any device which obviates calculations will be an additional link in the simplification of flying.

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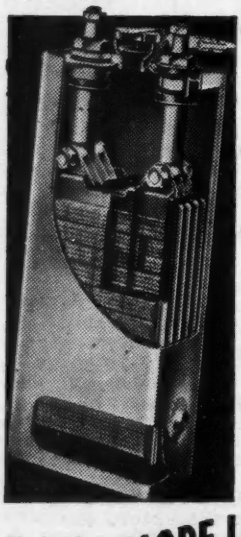

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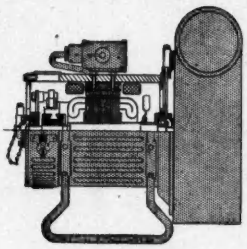

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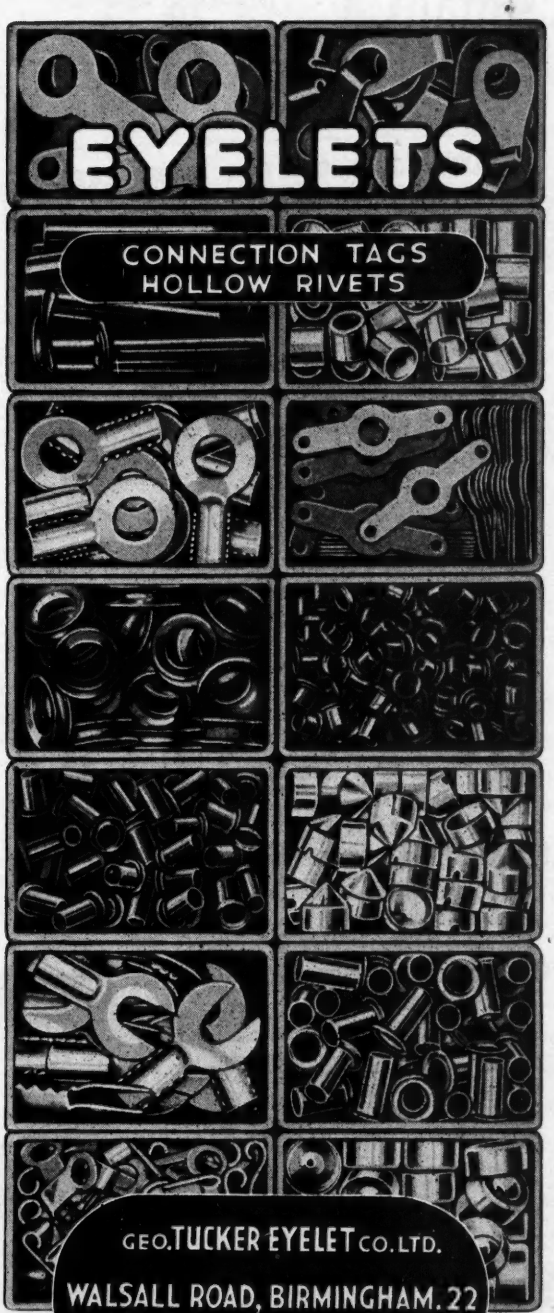

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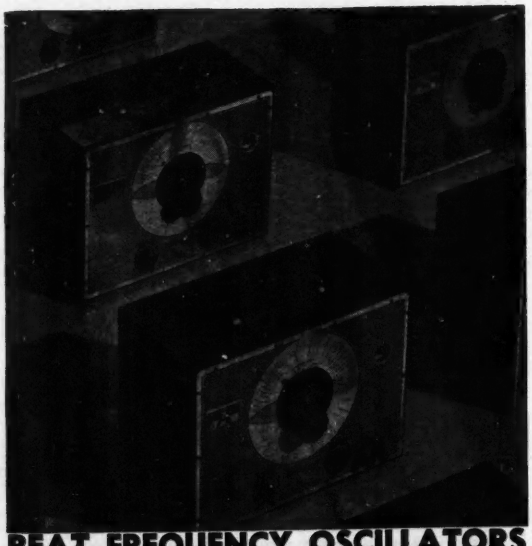

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PRECISION OPTICAL SYSTEM, producing fine line of light from any car headlight bulb, for scanning sound track of film direct into photo-cell, metal tube 1 in. long, ¼ in. dia., ⅛ in. focus, 52/-; full instructions free, goods by return. Cefa Instruments, 38a, York Street, Twickenham, Middlesex. 'Phone: POPesgrove 1597.

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

ELECTRIC LIGHT glass multi fittings and a good selection of radio and electrical spares at a low cost. S.A.E. for list to Dioptrical Vision Aerial Co., 17, Mill Hill, Deal, Kent.

SEND FOR FULLY descriptive leaflet on ex-Army portable heterodyne wavemeter, crystal oscillator, 2.9-25 Mcs., with spare valve and vibrator, **£6 15s.** complete. Carriage paid. M.O.S., 24, New Road, London, E.1.

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LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

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MECHANICAL ENGINEERS to the Electronic Industry. Precision and Optical Instruments of all types designed and constructed in collaboration with Electronic Engineers. Tecnaphot, Ltd., Mile Lane, Coventry.

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THE NAME TO NOTE for all kinds of radio and electrical metalwork to specification, modern rust-proofing, all shapes and sizes undertaken, and for tropical use. Components and sub assemblies executed to meet recognised wiring and material standards. Consultation, advice without obligation. Write: Department O1, Sea Rescue Equipment Ltd., Chiltern Works, Clarendon Road, Watford, Herts.

POLARISCOPES for glass strain determination, open stage, double eyepiece, sensitive tint, fields 2 in. to 10½ in. diameter. Details on request.

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OUR OWN FACTORY.—We have just acquired additional space on the premises and now have our own factory—primarily engaged on communications apparatus, transmitters and U.H.F. receivers. Mind you, it is only a little factory, but it is surprising sometimes what initiative and determined effort can do. WHEN you have a minute to spare—call in and see us—you will be quite interested.

Tele-Radio (1943), Ltd., 177, Edgware Road, London, W.2 (PAD. 6116).

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RADIO ENGINEER. Large radio firm in London area requires an Engineer to act as deputy to the head of its radio design section. The engineer concerned should have theoretical and practical experience of radio set design, preferably for the services. Write to Box 871, "Elec. Engg."

TECHNICAL DEVELOPMENT man required particularly for aerial design. Must be fully acquainted with design of aerial equipment for radio and television anti-static equipment and similar. Applicants must be capable of design and arranging production of equipment, testing, etc. North-west area. Particulars to Box 856, "Elec. Engg."

VACUUM PHYSICS LABORATORY in large concern situated in S.W. London area has vacancies for graduates; Honours Degree in physics, physical chemistry or electrical engineering and several years' research experience required. Salary, £600 per annum, upwards, according to age, qualifications and experience. Good conditions of employment and opportunity to publish original work. Assistants to above also required, and these men should have Honours Degree in physics. Mathematical ability will be regarded as an asset. Salary, £300 per annum, upwards, according to qualifications and experience. Apply in writing in the first instance to the Works Personnel Officer, Mullard Radio Valve Co., Ltd., New Road, Mitcham Junction, Surrey, quoting reference "K.6."

JUNIOR EXECUTIVE to take charge of Life Test Department, radio valve factory at Sunderland. Inter B.Sc., or H.N.C. standard with knowledge of electronics essential. Experience in valve industry desirable. Full particulars of education, experience and salary in first instance to Personnel Department, Cosmos Manufacturing Co., Ltd., Brimsdown, Enfield.

B.B.C. INVITES applications from men (British) for three posts in television section, research department, based firstly near Oxford, but at time to work London and elsewhere. For (a) and (b) recognised engineering qualifications, i.e., university degree or equivalent are essential and for (c) technical qualifications at least to Higher National Certificate. Training in communication engineering essential.

(a) Senior Engineer, grade max. £800 p.a. Must be thoroughly conversant with television technique, including practical experience. General knowledge optics and photographic technique an advantage. Organising ability, energy and initiative desirable. Duties comprise research in problems relating to development of television, both general principles and detail.

(b) Engineer, grade max. £600 p.a. Knowledge of television technique with practical experience an advantage. Duties include television research and development, with particular reference to circuits and equipment comprising a television channel. Normally works under supervision but ample scope for initiative.

(c) Assistant Engineer, grade max. £400 p.a. Must be keenly interested, though practical experience television technique not essential. Work includes all aspects of television research. Ample scope for initiative, but normally works under supervision.

Commencing salary dependent on age, qualifications and experience. Annual increments up to grade maximum, subject to favourable reports. Cost-of-living bonus £44 4s. p.a., and family allowances paid in addition to salary. Appointment to unestablished staff; entry to permanent staff for later consideration. Applications to Engineering Establishment Officer, Broadcasting House, London, W.1, with details of age and experience, not later than September 9, 1946.

LARGE FIRM in London requires Physicists for its research department. An honours degree in physics and some research experience is desirable. Salary according to qualifications and experience. Box 868, "Elec. Engg."

APPLICATIONS are invited for the position of Television Engineer, capable of creating and taking charge of department. Good up-to-date knowledge of design and development and first-class qualifications essential. Good salary to right man. Factory 30 miles London on S. Rly. Please write Box 870, "Elec. Engg."

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(CONTINUED ON NEXT PAGE)

CLASSIFIED ANNOUNCEMENTS (CONT.)

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MAN, UNDER 30, with B.Sc., in physics or engineering or Higher National Certificate in electrical engineering with specialised knowledge of electronics required for investigation and test of power cables and accessories. Write, stating qualifications and salary required to Staff Officer, British Insulated Callender's Cables, Ltd., Belvedere, Kent.

LINCOLNSHIRE JOINT CANCER Committee. Radiotherapy Centre, Scunthorpe. Applications are invited for the post of Technician in the physics department. The duties comprise the running of a well-equipped workshop, instrument making, laboratory work, darkroom work, X-ray plant maintenance, and the manufacture of radium applicators. Applicants must be fully trained and skilled in the operation of the usual workshop machinery. Electrical engineering qualifications and experience in any of the other aspects of the work would be advantageous. Salary as recommended by the Hospital Physicists Association, i.e., £375-£15-£450. Applications, giving full details of qualifications and experience, and accompanied by copies of two testimonials, should reach the Director, Radiotherapy Centre, Memorial Hospital, Scunthorpe, not later than September 30, 1946.

PERMANENT SHORE appointments available for skilled radio and radar installation and service engineers. Applicants must hold 1st or 2nd class P.M.G. Certificate of Proficiency in Radiotelegraphy; previous sea experience preferable but not essential. Write, stating qualifications and salary expected, to Box 878, "Elec. Engg."

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DEVELOPMENT LABORATORY Assistant required, must have thorough knowledge and experience of L.F., H.F., and acoustics. London Area. Box 880, "Elec. Engg."

RADIO ENGINEER required to take charge of works laboratory engaged on check testing all types of radio components and receivers. Previous experience in a mass production radio or light electrical factory very desirable. Technical qualifications at least equivalent to Grad. I.E.E. Age 35–45 years. Reply in writing to the Labour Manager, Philips Hamilton Works Limited, Wellhall Road, Hamilton, Scotland.

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RESEARCH LABORATORIES will be opening a factory in the High Wycombe district within the next three months, and vacancies will become available under the following classifications:—Executive Engineers, Research and Development Engineers, Technical Assistants, Instrument Makers, Tool Makers, Wiremen Assemblers, Wirewomen Assemblers, Laboratory Assistants (boys). Apply, stating age, experience, qualifications and salary required, by letter, to P.R.T. Laboratories, Ltd., Commonwood House, Nr. Chipperfield, Herts.

AERO ENGINE manufacturers have a position for an Electronic Engineer to specialise on measurement on vibration and allied problems in development department. Reply, giving particulars of technical training, experience, and salary required. Write Box 884, "Elec. Engg."

AN EXPERIENCED Technical Writer required by a London company for the preparation of advertisements, catalogues and operating manuals for industrial and scientific equipment concerned with instruments, electronics and physical apparatus. Applicants should have the requisite technical background and be capable of handling the firm's publicity work, but applications are invited from young men who, otherwise capable, could assume fuller responsibility for the latter duty after experience with the company. A permanent and progressive post offering excellent opportunities for a first-class man. Address, marked "Confidential," giving full details of experience, qualifications, salary expectations, etc., to Box 886, "Elec. Engg."

RADIO ENGINEER required for work on television receivers by an established company. An opportunity for a young man with B.Sc., or equivalent. Previous experience on modern pulse technique essential. Write Box D.6017. A.K.Advg., 212a, Shaftesbury Avenue, W.C.2.

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EX-SIGNALS MAJOR, public school, university, 6 years' technical officer, pre-war radio research, seeks responsible position. Box 867, "Elec. Engg."

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FOREMAN OF SIGNALS, 26, single, C. & G. qualifications, on release leave, seeks position anywhere U.K. with facilities for further study and experience. Sumner, Cowden, Hull.

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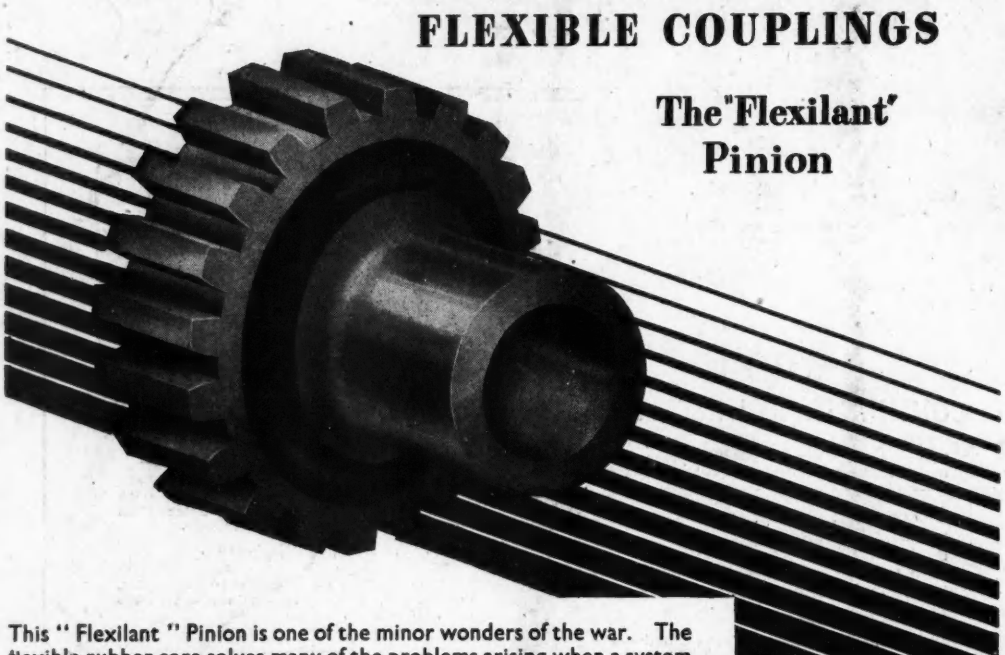
A STUDY IN FLEXIBLE COUPLINGS

The "Flexilant" Pinion



This " Flexilant " Pinion is one of the minor wonders of the war. The flexible rubber core solves many of the problems arising when a system is subject to violent changes of acceleration, or violent movement from forward to reverse. Before the inclusion of a flexible core, solid pinions continually failed under the strain imposed. For example, in searchlight mechanism when connected to wireless direction-finding equipment.

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